ARMY ORDNANCE

THE JOURNAL OF THE ARMY ORDNANCE ASSOCIATION

Founded 1920

Pledged to Industrial Preparedness as Our Strongest Guaranty of Peace

Volume XXI **MARCH-APRIL, 1941** **No. 125**

CONTENTS

Attack		Frontispiece
Export Control	William S. Culbertson	461
Ordnance Service in Our New Army	Brig. Gen. James K. Crain	464
Organization for Production		466
The Ordnance Establishment	*Facing*	468
Forging High-Explosive Shell	Arthur F. Macconochie	469
Synchronized Arms Production	Sanford E. Thompson	475
Mechanization on the March	(Pictorial)	477
Mass Production of Combat Tanks	F. A. Stevenson	485
The New Arms Plants		488
Statistical Methods and Quality	Capt. Leslie E. Simon	489
Rearmament Progress		493
Aircraft Armor	Horace J. Alter	497
Month by Month		499
The Road Ahead	An Editorial	501
Association Affairs		502
Ordnance in Review	Lieut. Col. Calvin Goddard	507
Ordnance Reserve		509
Professional Digest		513
Book Reviews		515
Index of Advertisers		574

Published by the Army Ordnance Association, Suite 806, Mills Building, Washington, D. C. Managing Editor: Lieut. Col. L. A. Codd, Ord. Res.; Associate Editor: R. E. Lewis, Jr. Authors are responsible for statements and opinions expressed in their articles. Copyright, 1941, by the Army Ordnance Association, Washington, D. C. Permission to republish is reserved.

Issued bimonthly. Single copy 75¢ (by mail). Subscription rate: continental U.S., $4.50 annually; foreign, $5.50, in advance. Entered as second-class matter, August 14, 1920, at the Post Office at Washington, D.C., under the Act of March 3, 1879. Additional second-class entry at the Post Office at Richmond, Va. Three weeks' notice before next issue required for change of address.

THE ARMY ORDNANCE ASSOCIATION

The Aims, Purposes, and National Officers of the Society

THE Army Ordnance Association is a national organization of American citizens pledged to industrial preparedness for war as our nation's strongest guaranty of peace.

The Association endeavors to keep alive an interest in and knowledge of the design, production and maintenance of munitions. Other than a few manufacturing arsenals—six in all—there is no peace-time industry for the production of ordnance. Should war unhappily come again, industrial America will be called upon to produce munitions in great quantity and of intricate and unusual design. In an emergency, time will not permit careful study or long preparation for the production of munitions. The problem is one of vital concern.

The Army Ordnance Association believes that the solution of this problem, based on experience, lies in an active organization at all times coöperating with the Government. The principal objective of the Association is an active membership of American citizens, on whom the duty of design and production of munitions will fall in war, who will have an accurate and authentic knowledge of the complex requirements of ordnance. "Peace insurance" in this form is the foremost aim of the Army Ordnance Association.

The Association is devoted solely to the national defense; it has no commercial interests, no political alliances, and no religious affiliations. It is not operated for profit: its income is expended in furthering its aims. Its officers and directors serve without remuneration. Membership, to which American male citizens are eligible, is four dollars a year. (Application on request.)

ARMY ORDNANCE, the journal of the Association, is published solely for the purpose of disseminating information on the progress of our munitions developments so that American industry may at all times know its responsibilities to the common defense.

The objectives of the Association as set forth in its Constitution are:

To assist in effecting industrial preparedness for war as being one of the nation's strongest guaranties of peace;

To keep available the highly specialized knowledge necessary for arming the manhood of the nation by stimulating interest in the design and production of ordnance material;

To promote mutual understanding and to effect coöperation with American scientists, inventors, engineers and manufacturers in civil life and the Regular and Reserve officers of the Ordnance Department;

To provide, when required, the services of competent committees to investigate and report upon special ordnance subjects;

To assist in developing and maintaining an efficient personnel, both commissioned and enlisted, for the units required for Ordnance Field Service in the event of an emergency;

To commemorate the services rendered by the industry of the nation and by the officers and civilian employees of the Ordnance Department in the wars in which the United States has been engaged.

Officers

President: BRIG. GEN. BENEDICT CROWELL, Cleveland, Ohio
1st Vice-President: COL. WILLIAM W. COLEMAN, Milwaukee, Wis.
2nd Vice-President: COL. FREDERICK H. PAYNE, Greenfield, Mass.
Treasurer: BRIG. GEN. CHAS. ELLIOT WARREN, New York, N. Y.
Counsel: BRIG. GEN. JOHN ROSS DELAFIELD, New York, N. Y.

Directors

MAJ. GEN. WILLIAM CROZIER, Washington, D. C.

MAJ. GEN. C. C. WILLIAMS, South Hamilton, Mass.
BRIG. GEN. SAMUEL MCROBERTS, New York, N. Y.
COL. ROBERT P. LAMONT, New York, N. Y.
COL. FRANK A. SCOTT, Cleveland, Ohio
COL. JAMES L. WALSH, New York, N. Y.
MR. EDMUND A. RUSSELL, Chicago, Ill.
COL. BRUCE CORNWALL, San Francisco, Calif.
MR. W. C. DICKERMAN, New York, N. Y.
COL. HARRY SCULLIN, St. Louis, Mo.
MR. J. B. DOAN, Cincinnati, Ohio
COL. THEODORE SWANN, Birmingham, Ala.
LIEUT. COL. LEROY HODGES, Richmond, Va.
COL. HERBERT A. GIDNEY, Pittsburgh, Pa.
MR. EARL B. GILMORE, Los Angeles, Calif.
COL. CHARLES H. TENNEY, Springfield, Mass.
MR. GEORGE W. ELLIOTT, Philadelphia, Pa.

Executive Vice-President and Secretary: LIEUT. COL. L. A. CODD, Ord. Res.
Assistant Secretary: FLORENCE G. FERRITER
Executive Offices: Mills Building, Pennsylvania Avenue at 17th Street, Washington, D. C.

LOCAL POSTS OF THE ASSOCIATION

The Officers and Headquarters of the Sixteen Chapters

BIRMINGHAM, ESTABLISHED DECEMBER 3, 1930

President: Theodore Swann. Vice-President: Lindley C. Morton. Directors: Thomas Martin, Oscar Wells, Hugh Morrow, W. D. Moore, Erskine Ramsay, L. E. Geohegan, Wade H. Oldham, R. C. Stobert. Treasurer: Richard J. Stockham. Secretary: W. F. Vander Hyden, 1908 Comer Building, Birmingham, Ala.

BOSTON, ESTABLISHED JUNE 30, 1925

President: C. S. Robinson. Vice-President: C. W. H. Cowdrey. Directors: T. L. Ames, R. J. Thanisch, M. T. Carney, A. E. Anderson, C. E. Fuller, W. Van Pattensteiger, R. E. Goho. Treasurer: Archibald McMillan. Secretary: J. S. Crawford, 140 Federal St., Boston, Mass.

CHICAGO, ESTABLISHED MAY 3, 1924

President: Edmund A. Russell. Vice-President: F. W. Parker, Jr. Directors: W. R. Wright, W. H. Damon, F. A. Preston, G. G. Thorp, W. B. Hobbs, C. A. Tibbals, Jr., Sterling Morton. Treasurer: W. H. Damon. Secretary: Donald Armstrong, 309 W. Jackson Boulevard, Chicago, Ill.

CINCINNATI, ESTABLISHED DECEMBER 10, 1925

President: August H. Tuechter. Vice-President: A. H. Pugh. Directors: E. A. Muller, F. L. Burke, Louis Schwitzer, C. W. Wheland, F. V. Geier, E. D. Smith, A. F. Hubbard, H. C. Knowles. Treasurer: J. D. Wyatt. Secretary: F. A. McMahon, 831 The Enquirer Building, Cincinnati, Ohio.

CLEVELAND, ESTABLISHED OCTOBER 25, 1940

President: Clifford F. Hood. Vice-Presidents: John C. McHannan and Rufus J. Wysor. Directors: Robert F. Black, Hosea T. Bradner, Ward M. Canaday, Fred Chapin, Frederick C. Crawford, Ben F. Hopkins, Adrian D. Joyce, Frank Purnell, Edward J. Thomas. Secretary-Treasurer: Harold M. Reedall, 1450 Terminal Tower, Cleveland, Ohio.

LEHIGH-BETHLEHEM, ESTABLISHED NOVEMBER 15, 1939

President: Richard M. Shepherd. 1st Vice-President: R. B. Gerhardt. 2nd Vice-President: Robert I. Felch. Treasurer: Leonard J. McKinley. Secretary: Robert Caemmerer, Lehigh University, Bethlehem, Pa.

LOS ANGELES, ESTABLISHED MAY 27, 1936

President: Earl B. Gilmore. Vice-President: Donald Douglas. Directors: W. H. Adams, Ralph O. Cragin, H. S. Hitchcock, M. A. Koffman, M. M. Mitchell, F. B. Cole. Treasurer: Samuel K. Rindge. Secretary: Ralph C. Scott, 2146 W. Adams Blvd., Los Angeles, Calif.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, ESTABLISHED JANUARY 20, 1922

President: David McNally. Vice-President: Teddy Walkowicz. Executive Committee: Raymond Koch, William Cadogan, Daniel Hulett, Francis Herlihy, Edward Hayes, Robert Boyer. Secretary-Treasurer: Herbert R. Moody, Department of Military Science, M.I.T., Cambridge, Mass.

MILWAUKEE, ESTABLISHED SEPTEMBER 26, 1928

President: W. W. Coleman. Vice-President: Eric H. Lichtenberg. Directors: A. G. Peter, Roger Sherman Hoar, R. E. Friend, D. P. Davies, J. E. DeLong, Max W. Babb, H. V. Kohler, Frank R. Bacon, Harold Falk. Secretary-Treasurer: C. W. Laumann, Bucyrus-Erie Company, So. Milwaukee, Wis.

NEW YORK, ESTABLISHED JUNE 15, 1921

President: Samuel McRoberts. 1st Vice-President: Crosby Field. 2nd Vice-President: James E. McNary. 3rd Vice-President: R. E. Gillmor. 4th Vice-President: Thomas E. Murray. Executive Committee: The Officers and Thomas F. Brown, C. Stewart Comeaux, W. C. Dickerman, Charles J. Hardy, H. M. Tillinghast, J. R. White. Treasurer: W. John Hoffman. Secretary: J. K. Clement, 80 Broadway, New York, N. Y.

PHILADELPHIA, ESTABLISHED DECEMBER 9, 1926

President: Philip H. Gadsden. Vice-President: George W. Elliott. Directors: E. T. Longstreth, J. L. Poultney, C. L. Jordan, John Q. MacDonald. Secretary: D. N. Hauseman (acting), 1417 Mitten Building, Philadelphia, Pa.

PITTSBURGH, ESTABLISHED FEBRUARY 24, 1927

President: Herbert A. Gidney. Vice-President: C. W. Heppenstall. Directors: Frank B. Bell, G. M. Sixsmith, S. L. Goodale, F. A. Merrick, W. F. Detwiler, J. D. Berg. Treasurer: G. Elkins Knable. Secretary: James L. Guion, 1032 New Federal Building, Pittsburgh, Pa.

ROCHESTER, ESTABLISHED APRIL 29, 1938

President: Frank J. Smith. Vice-President: Edward H. Halbleib. Directors: F. F. Hickey, James E. Gleason, A. F. Sulzer, J. K. Baylis, Carl S. Hallauer, David W. Sowers and William Kelly. Treasurer: Paul Folger. Secretary: Roy L. Bowlin, 1118 Mercantile Building, Rochester, N. Y.

ST. LOUIS, ESTABLISHED JANUARY 18, 1927

President: Edwin B. Meissner. Vice-President: W. C. Bliss. Directors: Willard R. Cox, E. W. Davis, H. B. Deal, W. H. Bixby, J. M. Kurn, Harry Scullin. Secretary-Treasurer: R. J. Hogan (acting), 1114 Market Street, St. Louis, Mo.

SAN FRANCISCO, ESTABLISHED OCTOBER 17, 1923

President: Roland L. Oliver. Vice-President: Leonard F. Fuller. Directors: D. C. Jackling, J. J. Thomas, Samuel Kahn, A. Leslie Oliver. Secretary-Treasurer: C. C. Harshman, 118 Federal Office Building, San Francisco, Calif.

WASHINGTON, ESTABLISHED NOVEMBER 18, 1925

President: F. H. Miles, Jr. Vice-President: Henry P. Erwin. Directors: Swagar Sherley, Fred E. Wright, LeRoy Hodges, Fred. H. Wagner, Hardee Chambliss, S. E. Reimel, Paul Weeks, Philip Schwartz. Treasurer: C. E. McRae. Secretary: R. O. Eliason, 806 Mills Building, Washington, D. C.

U. S. Army Signal Corps

Attack

ARMY ORDNANCE

Volume XXI MARCH-APRIL, 1941 No. 125

Export Control

Protecting Materials Vital to Our National Defense

William S. Culbertson*

TRADE policies in peace time have, or at least they should have, for their objective the creation of national wealth. But as a national rivalry advances, trade policies become increasingly instruments of political power. Their objectives become more and more the strength, rather than the wealth, of the nation.

These trade policies may be distinguished as: (1) Colonial trade policies, conspicuously used in the British and French Empires to establish economic preserves or monopolies; (2) Defensive trade policies, adopted by many countries to protect their national economics after the breakdown of the trading system which characterized the pre-World War international organization; (3) Aggressive trade policies, adopted primarily by Germany to compel other nations to accept her bilateral arrangements; (4) War-trade policies which nations adopt in a world at war to conserve goods at home and to promote phases of foreign trade—both imports and exports—so that they may contribute to national defense; (5) Economic warfare.

The United States, under the impact of the threat of war and then of war itself, has begun to adopt controls which reflect our foreign and military policy. Until now, no system of import control has been adopted, except as to the importation of arms, ammunition, and implements of war. But control applies now to about twenty per cent of our exports. Section 2 of the Neutrality Act of August 31, 1935, established a system of export licenses for arms, ammunition, and implements of war. With modifications, it has been continued by Section 5 of the Neutrality Act of May 1, 1937, and by Section 12 of the Neutrality Act of November 4, 1939. In its fifth report, the National Munitions Control Board states:

"THE fact that the exportation of arms, ammunition, and implements of war is subject to license at all times and that the United States customs authorities therefore habitually supervise strictly the exportation of these articles renders more certain and thorough the enforcement of embargoes which have been imposed on such exportations from time to time and of other special restrictions on exportation imposed under existing laws.

"The system of export licenses, moreover, enables the executive branch of the Government to observe closely the effect of policies which it may adopt in regard to the exportation of arms, ammunition, and implements of war, such as that originally announced by the Secretary of State on June 11, 1938, and reiterated and broadened in certain respects by the President on December 2, 1939, of discouraging the export of aircraft, aircraft parts, accessories, and armament and materials essential to aircraft manufacture to countries the armed forces of which are engaged in the bombing of civilian populations from the air. It should be noted that this policy still remains in effect, the Secretary of State having declared in his press conference on March 14, 1940, that the policy does not expire automatically . . .

"Another marked benefit of the system of export licenses has been that the United States Government is now in possession of complete and current information in regard to the exact quantities of arms, ammunition, and implements of war which leave the country, the country of destination of each shipment, and the identity of the exporters. This information is, of course, of particularly vital importance at a time like the present when several of the principal nations of the world are at war and when arms are being purchased in the United States in unprecedented quantities . . ." (House Document No. 876, Seventy-sixth Congress, third session, pp. 152-153).

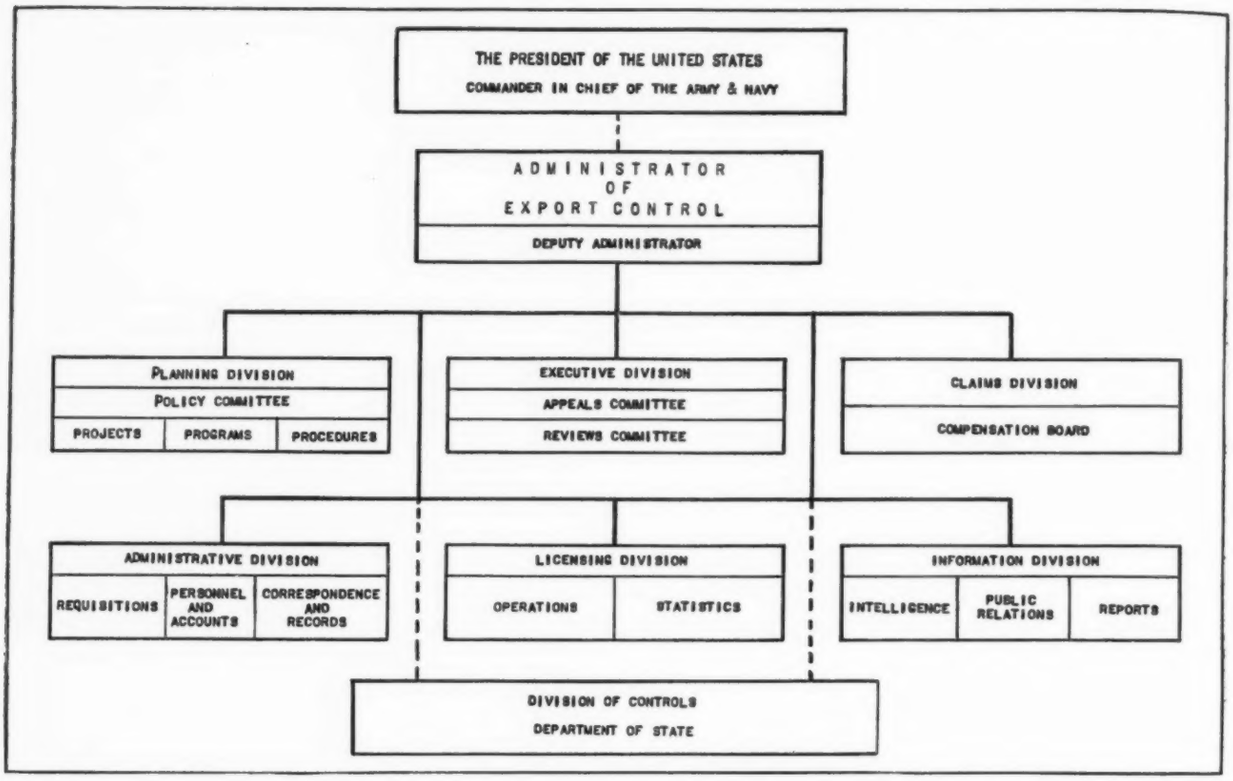
The above reference to the policy of "discouraging the export" of certain products to countries the armed forces of which are engaged in bombing civilian populations from the air, is worthy of some emphasis. Totalitarian governments would scorn a resort to the moral embargo. But such procedure is characteristic of a democracy. It records the indignation of the people and at the same time prepares public opinion for an export embargo enforced by law.

A letter dated December 15, 1939, and implementing the moral embargo was addressed by the Department of State to interested persons and companies registered with the Secretary of State. It read in part:

"In view of the policy to which the President referred, the Department hopes that it will not receive any application for a license to authorize the exportation, direct or indirect, of any aircraft, aircraft armament, aircraft engines, aircraft parts, aircraft accessories, aërial bombs or torpedoes to countries the armed forces of which are engaged in such bombing or machine gunning."

THE Division of Controls of the Department of State is the agency through which the Secretary of State exercises the functions assigned to him by the Joint Resolution of November 4, 1939, and by other laws; for example, the control of the exportation of tin scrap and helium gas. Its chief is Joseph C. Green. In this division, consideration is given to policy affecting international traffic in arms, American neutrality, and controls established to prevent the involvement of the United States in war and to aid national defense. All licenses for exports are issued through this division.

*Author: "International Economic Policies" (1925); "Reciprocity" (1937), and other works on economic policy. Head, Department of Economics, School of Foreign Service, Georgetown University, Washington, D. C. Formerly vice-chairman of the U. S. Tariff Commission, Minister to Rumania and Ambassador to Chile. Major, Reserve Corps, U. S. Army.



The Administration of Export Control

The people of the United States awoke leisurely to the danger of war. The Hitler war machine moved westward. Paris fell on June 14, 1940. The French Army was destroyed. The American people began to see the meaning of the possible destruction of the British fleet—up to then they accepted it in much the same way that we accept the sunrise. National defense became a policy. We talked of the mobilization of our industries for producing the implements of war, especially airplanes; we talked of a 2-ocean navy; we talked of the conscription of our man power. These were the subjects on which public attention was chiefly centered.

But economic defense began to receive attention also. The President approved, on July 2, 1940, a law enacted by Congress to expedite the strengthening of national defense. Its section 6 reads in part as follows:

"Whenever the President determines that it is necessary in the interest of national defense to prohibit or curtail the exportation of any military equipment or munitions, or component parts thereof, or machinery, tools, or material or supplies necessary for the manufacture, servicing or operation thereof, he may by proclamation prohibit or curtail such exportation, except under such rules and regulations as he shall prescribe . . ."

On the same date on which he approved this act the President put it into effect by proclamation. By this proclamation, he vested the administration of section 6 in an Administrator of Export Control. He also, by military order, appointed Brig. Gen. Russell L. Maxwell as Administrator. General Maxwell's years of service in the War Department fit him in a very special sense for the performance of the important duties assigned to him by the President.

The proclamation, then, after enumerating strategic and critical raw materials and manufactured articles subjected to control, continues as follows:

"And I do hereby empower the Secretary of State to issue licenses authorizing the exportation of any of the said articles and materials the exportation of which is not already subjected to the requirement that a license be obtained from the Secretary of State authorizing their exportation, and I do hereby authorize and enjoin him to issue or refuse to issue licenses authorizing the exportation of any of the articles or materials listed above in accordance with the aforesaid rules and regulations or such specific directives as may be, from time to time, communicated to him by the Administrator of Export Control.

"And I do hereby admonish all citizens of the United States and every person to abstain from every violation of the provisions of section 6 of the act above set forth, of the provisions of this proclamation, and of the provisions of such regulations as may be issued thereunder, and I do hereby warn them that all violations of such provisions will be rigorously prosecuted.

"And I do hereby enjoin upon all officers of the United States, charged with the execution of the laws thereof, the utmost diligence in preventing violations of the said act, of this my proclamation, and of any regulations which may be issued pursuant hereto, and in bringing to trial and punishment any offenders against the same."

Section 6 of the Act of July 2nd refers to rules and regulations, and these too, signed by the President, were made public on that date. Two of the rules may be quoted:

"The Secretary of State will issue export licenses to authorize proposed shipments of the said articles and materials to applicants who have duly filled out the appropriate form when I have determined that the proposed exportation would

not be detrimental to the interests of the national defense.

"Regulations contained in the pamphlet 'International Traffic in Arms—Laws and Regulations Administered by the Secretary of State Governing the International Traffic in Arms, Ammunition, and Implements of War and Other Munitions of War,' seventh edition, will continue to govern the exportation of arms, ammunition, and implements of war and tin-plate scrap except that export licenses will not be issued when in any case I shall have determined that the proposed shipment would be contrary to the interests of the national defense."

The practical working of export control is not always easy to follow for the citizen on the outside. Every once in a while it goes under ground and is lost to public view. A working arrangement evidently exists between the Division of Controls in the Department of State and the Administrator of Export Control. Both contribute to the decisions reached. Other permanent and defense divisions of the Government advise and help determine questions of policy. These relationships are defined in intergovernmental agreements.

FOUR categories of materials and articles are now distinguishable under the proclamations making export control effective:

1. Arms, ammunition, and implements of war as defined in the President's proclamation of May 1, 1937. These are the products which could not be exported to countries at war until Congress lifted the arms embargo in 1939. However, licenses must be obtained for their exportation and may now be refused in the interest of national defense.

2. Strategic and critical materials considered by the military and naval forces necessary for national defense. These include copper, petroleum, iron and steel, aluminum, asbestos, manganese, quinine, rubber, toluol, etc., and specialized equipment of various kinds.

3. Machine tools. To make this item concrete, note the following tools listed for export control in the first proclamation under the Law of July 2nd: melting and casting tools (electric melting furnaces, foundry ladles); tools for casting into forms (power hammers, bolt and nut forging, rolling-mill machinery); cutting or grinding tools, power-driven (turret lathes, gun-boring mills); welding machines (electric, acetylene torches).

4. A fourth category subjected to export control includes "any plans, specifications, or other documents containing descriptive or technical information of any kind" useful in the design, construction, or operation of equipment which can be used for the production of aviation motor fuel (President's proclamation, September 12, 1940). This policy is not only for the purpose of conserving processes and information useful for national defense but also of making more effective the embargo against countries the armed forces of which are engaged in unprovoked bombing or machine gunning of civilian populations from the air. Up to November 1, 1941, licenses for the export of materials and articles had been refused in the amount of $113,000,000.

The refusal of licenses to export materials and articles implies that they are absorbed in the program of national defense. Probably officials of the Government use their good offices to put producers who are refused licenses in touch with the buying agencies of the Government.

But in some cases, materials and articles for which export licenses were refused had been sold and the title passed to a foreign purchaser. In certain of these cases, the foreign purchaser either would not or could not resell the goods in the United States. Machine tools were affected in particular. Following the enactment of a law giving him the authority, the President, on October 15, 1940, issued regulations governing the requisitioning and taking over for the use of the United States of such materials and articles. The Secretary of War and the Secretary of the Navy, acting jointly through the Army and Navy Munitions Board, were directed "to determine the necessity for the requisitioning of any equipment, munitions or machinery, tools, materials or supplies necessary for the manufacture of munitions, or the servicing or operation of facilities for the national defense, and to determine whether in any case it is in the public interest to sell, or otherwise dispose of, any of the articles and materials so requisitioned. The administration of the other provisions of the act has been vested in the Administrator of Export Control."

General Maxwell in an address on export control on December 19th, 1940, said: "Our objectives in this particular respect are twofold: first, to retain in this country the articles and materials needed to arm ourselves, and secondly, to facilitate the exportation of those articles and materials not needed to foreign countries in the interest of maintenance of our foreign trade."

TO achieve the first objective mentioned by General Maxwell, controls of exports will be enlarged; we may in time also have control of imports. We are committed to participation in the conflict now sweeping the world. Our participation at present is economic—strengthening our own power to fight, aiding the British Empire and China to fight. We may move no further into the war. But the position we now occupy is fraught with heavy responsibility. We must turn the materials and products which are under our control first into the production of the means for our defense and then into the military organization of those countries which fight for the sort of world in which we believe.

Let me say a word in conclusion about the second objective mentioned by General Maxwell. It is a good sign that in the administration of export control we are not forgetting our foreign trade. Control thus pays tribute to its antithesis. A paradox of the military and economic struggle between the nations is that the democracies must adopt in self-defense the methods and instruments of the totalitarian states. Export control is a totalitarian method, useful to organize military strength but destructive of wealth and well-being.

The British are seeking in the midst of their life-and-death struggle to preserve and promote their foreign trade. We, too, should not neglect our trading areas and new trade frontiers, even at a time when we are concentrating on economic defense. Nor is it too soon to recognize what our economic problem will be after the war. National strength may evolve under controls; national wealth will not.

Business men should do some planning for themselves. The program of national defense gives impetus to collectivistic methods and organization which are necessary in mobilization. But business men should lose no opportunity to emphasize that the time for demobilization is coming. The moth survives only if it maintains its self-control and avoids the tempting flame of the candle. We can patch up a sort of existence after the war with Government loans, subsidies, and controls. But only private enterprise and venture capital can create the material basis on which alone institutions of a free people can endure and evolve.

Ordnance Service in Our New Army

A Balanced Force for Field Maintenance and Supply

Brig. Gen. James K. Crain*

THE functions of the Field Service of the U. S. Army are storage, distribution, inspection, and maintenance of ordnance equipment and ammunition. The agencies and units that perform these functions are the following: the Field Service Division of the Office of the Chief of Ordnance; Field Service arsenals and depots; corps-area, air-district and post Ordnance officers; GHQ Air Force, army, corps, and division Ordnance officers, and Ordnance tactical units under their direction.

The organization in the Ordnance Office is as follows: The Military Organization and Publications Division is charged with developing the organization of Ordnance tactical units and with preparing the technical manuals, standard nomenclature lists, and other publications required by field service. The Ammunition Supply Division, which in the present emergency has performed the important job of selecting sites and making layouts for additional ammunition depots, is charged with the four field-service functions with respect to ammunition. The Equipment Division is charged with the same functions with respect to ordnance equipment and accessories. The Utilities Division performs the engineering work required in planning new installations and in the maintenance of buildings and utilities under the direction of Field Service.

The principal items of ordnance equipment have been placed in two issue categories. The first category is said to be "controlled," and its distribution is directed by the War Department; the second category is called "credit," and its distribution is directed by the corps-area and GHQ Air Force commanders. A few words on this "credit" system may be useful. The credits are issued by the War Department on various Ordnance depots and in effect form a synthetic corps-area depot. The work of ordering the credit items to organizations is decentralized to the corps-area and Air Force commanders, and Washington is relieved of a material burden of correspondence, for the commanders are informed by the credits of the resources available to them and have complete control of their disposition. The psychological value of this is important. Credits are used with respect to ammunition as well as to equipment; they should not be confused with allowances, which are covered in various regulations.

The corps-area commanders are charged with the supply of troops within their corps areas. There are certain exceptions to this statement, but, in general, each corps-area headquarters takes the rôle of supply base within its jurisdiction.

Inspection and maintenance duties cannot be so readily differentiated initially for various reasons. The principal factors in inspection and its corollary—repair—are personnel, tools, and spare parts. These are available to corps areas and to armies, and they are superimposed upon one another geographically. Further, corps-area organizations have existed for some time, whereas the larger tactical units have been created recently.

In 1928, the then Chief of Ordnance, Maj. Gen. C. C. Williams, convened a board of Ordnance officers to recommend an organization that would meet Ordnance responsibilities with armies in the field. The members of the board had served in the World War. They based their report upon certain principles which had not been followed in 1917. The chief of these were economy of force and control of Ordnance units by Ordnance officers responsible for Ordnance functions. In addition, remedies were suggested for remembered deficiencies of 1917.

In 1939, in the general reorganization of the Army, a complete revamping of the Ordnance ground-force tactical units took place. The Air Force Ordnance tactical units likewise underwent a material change. This change had begun in 1935 under the direction of Brig. Gen. R. L. Maxwell, Ord. Dept., who initiated the first real Ordnance service provided for aviation units. By his efforts, a definite scheme of organization and functioning was set up with the Air Force. His successor at Air Force headquarters, Lieut. Col. E. A. Lynn, likewise has striven for a coördinated Ordnance aviation organization. The efforts of these two officers have prevented a Topsy-like growth such as took place with ground units in 1917 and which continued on the books for twenty years.

LET us now discuss briefly the present Ordnance field organization. The Ordnance ground forces include the following:

Division Ordnance Section.—As the name implies, this is a section of the triangular division headquarters company. It is provided with basic transportation and the hand tools and spare parts necessary for limited repair work in the division. It also performs the administrative functions involved in ammunition supply. The new Staff Officers' Field Manual places the division Ordnance officer with the forward echelon of division headquarters. This division Ordnance section is the only instance of Ordnance personnel being attached to and dependent upon another organization for administration and housekeeping. This condition will require careful consideration by the division commander and his general staff to prevent some of the evils of 1917 when Ordnance personnel and equipment at times were diverted from Ordnance functions.

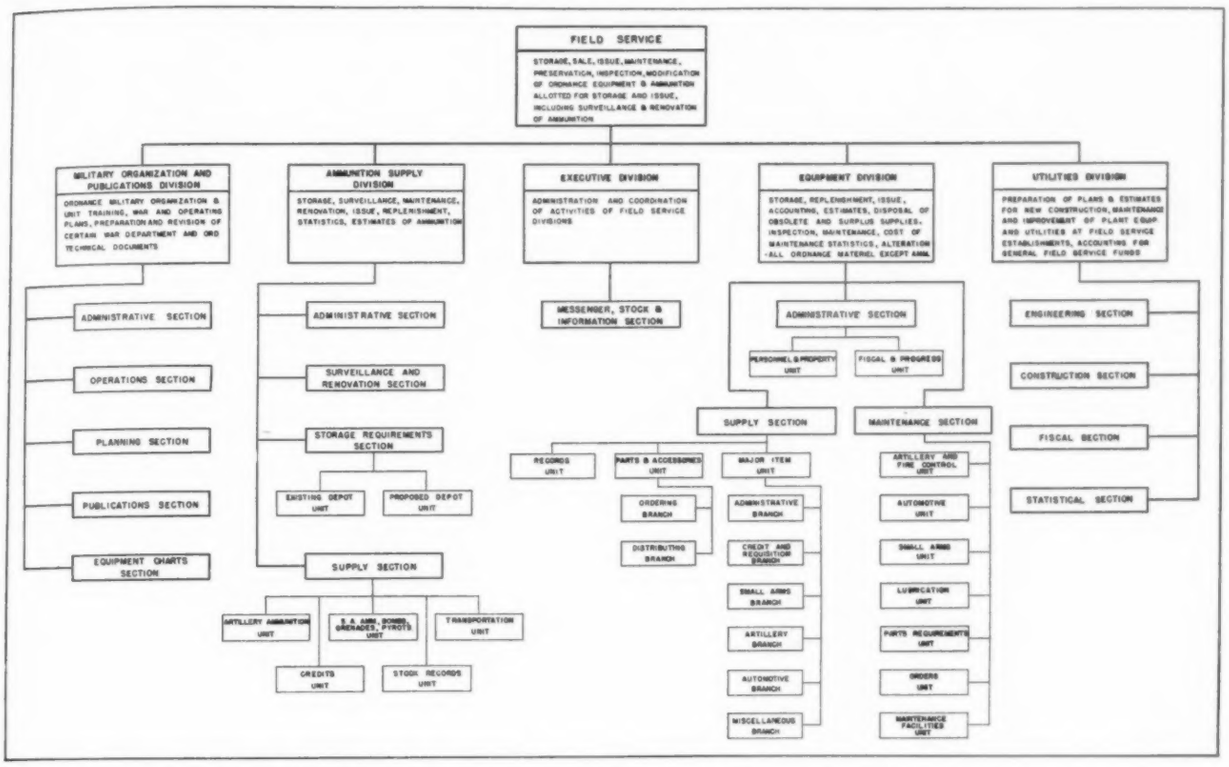
Corps Ordnance Battalion.—This comprises three medium-maintenance companies and functions under the corps Ordnance officer. The battalion supports the division Ordnance sections and maintains nondivisional units. An excellent article on the functioning of the corps battalion by Capt. J. M. Colby appeared in the November-December 1940 issue of ARMY ORDNANCE (Vol. XXI, No. 123, p. 208).

Army Ordnance Units.—Each army has one supply-and-maintenance battalion and two ammunition battalions. The supply-and-maintenance battalion contains one depot company, two medium-maintenance companies and one heavy-maintenance company. Each ammunition battalion contains six ammunition companies. These battalions function under the army Ordnance officer.

The depot company operates the army ordnance depot for ordnance general supplies. It also may assist the maintenance

*Chief of Field Service, Ordnance Department. Brigadier General, U. S. Army.

This is an address delivered before the Washington Post, Army Ordnance Association, January 14, 1941, the Raleigh Hotel, Washington, D. C.


FIELD SERVICE
STORAGE, SALE, ISSUE, MAINTENANCE, PRESERVATION, INSPECTION, MODIFICATION OF ORDNANCE EQUIPMENT & AMMUNITION ALLOTTED FOR STORAGE AND ISSUE, INCLUDING SURVEILLANCE & RENOVATION OF AMMUNITION
MILITARY ORGANIZATION AND PUBLICATIONS DIVISION
ORDNANCE MILITARY ORGANIZATION & UNIT TRAINING, WAR AND OPERATING PLANS, PREPARATION AND REVISION OF CERTAIN WAR DEPARTMENT AND ORD TECHNICAL DOCUMENTS
AMMUNITION SUPPLY DIVISION
STORAGE, SURVEILLANCE, MAINTENANCE, RENOVATION, ISSUE, REPLENISHMENT, STATISTICS, ESTIMATES OF AMMUNITION
EXECUTIVE DIVISION
ADMINISTRATION AND COORDINATION OF ACTIVITIES OF FIELD SERVICE DIVISIONS
EQUIPMENT DIVISION
STORAGE, REPLENISHMENT, ISSUE, ACCOUNTING, ESTIMATES, DISPOSAL OF OBSOLETE AND SURPLUS SUPPLIES, INSPECTION, MAINTENANCE, COST OF MAINTENANCE STATISTICS, ALTERATION -ALL ORDNANCE MATEREL EXCEPT AAM.
UTILITIES DIVISION
PREPARATION OF PLANS & ESTIMATES FOR NEW CONSTRUCTION, MAINTENANCE AND IMPROVEMENT OF PLANT EQUIP. AND UTILITIES AT FIELD SERVICE ESTABLISHMENTS, ACCOUNTING FOR GENERAL FIELD SERVICE FUNDS
ADMINISTRATIVE SECTION
OPERATIONS SECTION
PLANNING SECTION
PUBLICATIONS SECTION
EQUIPMENT CHARTS SECTION
ADMINISTRATIVE SECTION
SURVEILLANCE AND RENOVATION SECTION
STORAGE REQUIREMENTS SECTION
EXISTING DEPOT UNIT
PROPOSED DEPOT UNIT
SUPPLY SECTION
ARTILLERY AMMUNITION UNIT
S. A. AMM. BOMBS, GRENADES, PYROTS UNIT
TRANSPORTATION UNIT
CREDITS UNIT
STOCK RECORDS UNIT
MESSENGER, STOCK & INFORMATION SECTION
ADMINISTRATIVE SECTION
PERSONNEL & PROPERTY UNIT
FISCAL & PROGRESS UNIT
SUPPLY SECTION
MAINTENANCE SECTION
RECORDS UNIT
PARTS & ACCESSORIES UNIT
MAJOR ITEM UNIT
ORDERING BRANCH
DISTRIBUTING BRANCH
ADMINISTRATIVE BRANCH
CREDIT AND REQUISITION BRANCH
SMALL ARMS BRANCH
ARTILLERY BRANCH
AUTOMOTIVE BRANCH
MISCELLANEOUS BRANCH
ARTILLERY AND FIRE CONTROL UNIT
AUTOMOTIVE UNIT
SMALL ARMS UNIT
LUBRICATION UNIT
PARTS REQUIREMENTS UNIT
ORDERS UNIT
MAINTENANCE FACILITIES UNIT
ENGINEERING SECTION
CONSTRUCTION SECTION
FISCAL SECTION
STATISTICAL SECTION

FIELD SERVICE ORGANIZATION OF THE ORDNANCE DEPARTMENT, U. S. ARMY

companies in stocking spare parts. It is preferable, however, to ship spare parts from the communication zone direct to the heavy-maintenance company. The three maintenance companies of the army (reënforced by GHQ maintenance companies when necessary) maintain the ordnance of army troops and support the corps Ordnance battalions. The heavy company is provided with heavier equipment than that of the medium companies. Certain heavy-maintenance companies of the GHQ reserve will be provided with special equipment for tank maintenance and will be given special training for that work. The two army ammunition battalions will operate the army ammunition depots. This operation includes the handling of ammunition in and out of the depots, the reclaiming and sorting of salvaged ammunition, and similar depot duties. They will be assisted when peak loads occur (during the initial stocking of a large depot, for example) by labor troops from the Quartermaster units.

GHQ reserve will have Ordnance units in a proper ratio to the combat units. When these latter are attached to armies, the GHQ Ordnance units will reënforce the army Ordnance units. A new type unit, the railway artillery maintenance company, is found in the GHQ reserve. Two of these companies will be organized in 1941. Their shops will be mounted on railway cars.

Armored Force Ordnance Units.—An Ordnance maintenance battalion is assigned to each mechanized division. This battalion is composed of a headquarters company and two Ordnance companies, maintenance, armored division. Two maintenance companies are provided to give flexibility of operation and movement. The headquarters company forms a base for the other two companies. The Ordnance maintenance battalion provides the normal ordnance service for the armored division; if the division is attached to an army, the battalion may be helped by the army Ordnance units.

The Ordnance Air Force organization comprises the following:

Ordnance Company, Aviation (bombardment, pursuit, composite).—An appropriate company of the foregoing types is assigned to each Air Corps combat group. The Ordnance aviation companies contain a platoon for each squadron in the Air Corps group. This organization is to meet possible decentralization by squadrons. These companies are equipped and trained to handle the ammunition, including bombs, up to the airplane; also the inspection and maintenance of armament.

Ordnance Company, Aviation (air-base).—One of these companies is provided for each air base. It maintains a supply of ordnance equipment and provides a base for the Ordnance companies assigned to air groups. It is provided with mobile shop equipment and performs maintenance work beyond the capability of the Ordnance companies with the groups.

The air-district and air-force headquarters include Ordnance sections with supervisory and administrative functions. These echelons of the Air Force do not have operating Ordnance units.

A station complement, not a part of a tactical unit, is provided at the military posts in the United States. This station complement is left behind when tactical units take the field and thus permits those units to leave promptly and at full strength. The station complements may be augmented by civilian personnel.

It is believed that a satisfactory organization has been formulated for Ordnance Field Service. New types of maintenance vehicles and equipment are being provided for the various companies. A number of the units will be organized and trained during 1941. The General Staff has planned a balanced field force. The Ordnance field units will meet their responsibilities.

Organization for Production

The Ordnance System of Decentralized Operation

HERE is published the roll call of Ordnance production establishments now—or soon to be—in operation. The vast industrial organization here outlined stems from the Office of the Chief of Ordnance in Washington; but a cardinal principle of Ordnance has always been: centralized control with decentralized operation. Under this principle the Ordnance district system, embracing the entire United States, has been in existence for the past twenty years. That system, under civilian leadership, has conducted plant surveys and allocations running back practically to the World War. Ordnance district and regional headquarters are shown in red on the map facing page 468. The various Ordnance districts are outlined in red. The numerals on the map correspond with those in this list.

Also listed are the Ordnance establishments which were in operation prior to 1941 (shown in green on the map). These include the "old-line" arsenals and depots. Together with the district system for private industry, these comprise the Ordnance team which is now producing in satisfactory measure.

Finally there are the new facilities for the production of ordnance (shown in yellow). These comprise thirty-seven new plants for the production of ordnance equipment for which private facilities either did not exist at all or else existed in entirely inadequate quantity.

On page 488 is published a résumé of the types of contracts under which new facilities are constructed. The new Ordnance facilities are under Plan I—Government funds with operation by private management.

Ordnance District and Regional Headquarters

1. BOSTON ORDNANCE DISTRICT—Room 1501, 140 Federal Street, Boston, Mass. *Chief:* Col. Charles H. Tenney; *Assistant Chiefs:* Alvin Simonds and Millar Brainard; *Executive Officer:* Lieut. Col. James S. Crawford.

2. HARTFORD ORDNANCE DISTRICT—95 State Street, Springfield, Mass. *Chief:* Col. Frederick H. Payne; *Assistant Chiefs:* Joseph B. Ely and Philip B. Stanley; *Executive Officer:* Col. Robert Sears.

3. NEW YORK ORDNANCE DISTRICT—80 Broadway, New York, N. Y. *Chief:* Brig. Gen. Samuel McRoberts; *Assistant Chief:* Col. Thomas F. Brown; *Executive Officer:* Col. John K. Clement.

4. ROCHESTER ORDNANCE DISTRICT—1132 Mercantile Building, Rochester, N. Y. *Chief:* Erwin R. Davenport; *Assistant Chief:* Howard O. Babcock; *Executive Officer:* Lieut. Col. Roy L. Bowlin.

5. PHILADELPHIA ORDNANCE DISTRICT—1400 Mitten Building, Philadelphia, Pa. *Chief:* Charles J. Ingersoll; *Executive Officer:* Maj. D. N. Hauseman.

6. WILMINGTON ORDNANCE REGION—1466 Nemours Building, Wilmington, Del. *Executive Officer:* Maj. John P. Harris.

7. PITTSBURGH ORDNANCE DISTRICT—1032 New Federal Building, Pittsburgh, Pa. *Chief:* Frank B. Bell; *Assistant Chief:* John D. Berg; *Executive Officer:* Lieut. Col. James L. Guion.

8. CLEVELAND ORDNANCE DISTRICT—1450 Terminal Tower Building, Cleveland, Ohio. *Chief:* Col. Winthrop Withington; *Assistant Chiefs:* Carl C. Gibbs and George C. Brainard; *Executive Officer:* Maj. H. M. Reedall.

9. CINCINNATI ORDNANCE DISTRICT—Room 831, The Enquirer Building, Cincinnati, Ohio. *Chief:* Edward A. Muller; *Assistant Chiefs:* Frederick V. Geier and Harvey C. Knowles; *Executive Officer:* Lieut. Col. Fred A. McMahon.

10. BIRMINGHAM ORDNANCE DISTRICT—1008 Comer Building, Birmingham, Ala. *Chief:* Col. Theodore Swann; *Assistant Chiefs:* George M. Morrow, Jr. and Allen Rushton; *Executive Officer:* Lieut. Col. W. F. Vander Hyden.

11. DETROIT ORDNANCE DISTRICT—1832 National Bank Building, Detroit, Mich. *Chief:* Alex Dow; *Assistant Chiefs:* Frank W. Steere and William B. Hurley; *Executive Officer:* Lieut. Col. Richard Z. Crane.

12. CHICAGO ORDNANCE DISTRICT—Room 222, 309 W. Jackson Boulevard, Chicago, Ill. *Chief:* Frederick A. Preston; *Assistant Chiefs:* C. Raymond Messinger and Phelps Kelly; *Executive Officer:* Col. Donald Armstrong.

13. ST. LOUIS ORDNANCE DISTRICT—935 U. S. Custom and Court House, St. Louis, Mo. *Chief:* Col. Harry Scullin; *Assistant Chiefs:* Willard R. Cox and H. B. Deal; *Executive Officer:* Maj. Randall J. Hogan.

14. LOS ANGELES ORDNANCE REGION—409 Chamber of Commerce Building, Los Angeles, Calif. *Executive Officer:* Lieut. Col. A. R. Baird.

15. SAN FRANCISCO ORDNANCE DISTRICT—118 U. S. Federal Office Building, San Francisco, Calif. *Chief:* Samuel Kahn; *Assistant Chiefs:* Dean Witter and Alexander H. Brawner; *Executive Officer:* Col. K. B. Harmon.

Arsenals and Depots Prior to 1941

16. WATERTOWN ARSENAL—Watertown, Mass. Gun carriages and forgings. *Commanding Officer:* Brig. Gen. R. W. Case.

17. SPRINGFIELD ARMORY—Springfield, Mass. Machine guns and rifles. *Commanding Officer:* Brig. Gen. G. H. Stewart.

18. WATERVLIET ARSENAL—Watervliet, N. Y. Cannon. *Commanding Officer:* Brig. Gen. A. G. Gillespie.

19. RARITAN ORDNANCE DEPOT—Metuchen, N. J. Loading plant and storage. *Commanding Officer:* Lieut. Col. John H. Woodbury.

20. PICATINNY ARSENAL—Dover, N. J. Smokeless powder, high explosives, and loaded ammunition. *Commanding Officer:* Brig. Gen. E. M. Shinkle.

21. FRANKFORD ARSENAL—Philadelphia, Pa. Fire-control instruments, small-arms ammunition, and artillery ammunition. *Commanding Officer:* Brig. Gen. W. P. Boatwright.

22. DELAWARE ORDNANCE DEPOT—Pedricktown, N. J. Loading plant and storage. *Commanding Officer:* Lieut. Col. J. E. Brown.

23. NANSEMOND ORDNANCE DEPOT—Portsmouth, Va. Loading plant and storage. *Commanding Officer:* Lieut. Col. C. C. Terry.

24. CURTIS BAY ORDNANCE DEPOT—South Baltimore, Md. Loading plant and storage. *Commanding Officer:* Lieut. Col. H. A. Willis.

25. ABERDEEN PROVING GROUND—Md. Proof of ammunition and equipment. *Commanding Officer:* Brig. Gen. J. B. Rose.

26. CHARLESTON ORDNANCE DEPOT—North Charleston, S. C. Loading plant and storage. *Commanding Officer:* Col. Roger Taylor.

27. AUGUSTA ORDNANCE DEPOT—Augusta, Ga. General supplies and storage. *Commanding Officer:* Lieut. Col. A. H. Skinner.

28. ERIE ORDNANCE DEPOT—Lacarne, Ohio. Storage. *Commanding Officer:* Lieut. Col. Thomas K. Vincent.

29. SAVANNA ORDNANCE DEPOT—Savanna, Ill. Loading plant and storage. *Commanding Officer:* Lieut. Col. L. P. Crim.

30. ROCK ISLAND ARSENAL—Rock Island, Ill. Gun carriages and combat vehicles. *Commanding Officer:* Brig. Gen. N. F. Ramsey.

31. SAN ANTONIO ORDNANCE DEPOT—San Antonio, Tex. General supplies and storage. *Commanding Officer:* Col. J. G. Booton.

32. OGDEN ORDNANCE DEPOT—Ogden, Utah. Storage. *Commanding Officer:* Maj. J. W. Proctor.

33. BENICIA ORDNANCE DEPOT—Benicia, Calif. Storage. *Commanding Officer:* Col. P. J. R. Kiehl.

New Plants, Works, Depots and Proving Ground

34. RAVENNA ORDNANCE DEPOT—Ravenna, Ohio. Loading plant and storage. *Commanding Officer:* Lieut. Col. R. S. Chavin.

35. ANNISTON ORDNANCE DEPOT—Anniston, Ala. Storage. *Commanding Officer:* Capt. John W. Quickmire.

36. JEFFERSON PROVING GROUND—Madison, Ind. Proof of equipment and ammunition. *Commanding Officer:* Lieut. Col. DeR. C. Cabell.

37. WINGATE ORDNANCE DEPOT—Fort Wingate, N. Mex. Storage. *Commanding Officer:* Lieut. J. C. Wilson.

38. UMATILLA ORDNANCE DEPOT—Hermiston, Oreg. Storage. *Commanding Officer:* Capt. E. E. Reynolds.

39. HARTFORD MACHINE GUN PLANT—*Contractor:* Colt's Patent Fire Arms Manufacturing Company, Hartford, Conn. *Jurisdiction:* Hartford Ordnance District.

40. HARTFORD LIGHT WEAPONS PLANT—*Contractor:* Colt's Patent Fire Arms Manufacturing Company, Hartford, Conn. *Jurisdiction:* Hartford Ordnance District.

41. UTICA MACHINE GUN PLANT—*Contractor:* Savage Arms Corporation, Utica, N. Y. *Commanding Officer:* Capt. R. H. Coombs.

42. SYRACUSE MACHINE GUN PLANT—*Contractor:* General Motors Corporation, 57th & Broadway, New York, N. Y. *Commanding Officer:* Maj. J. J. Breen.

43. FLINT MACHINE GUN PLANT—*Contractor:* General Motors Corporation, 57th & Broadway, New York, N. Y. *Commanding Officer:* Maj. J. J. Breen.

44. DAYTON MACHINE GUN PLANT—*Contractor:* General Motors Corporation, 57th & Broadway, New York, N. Y. *Commanding Officer:* Maj. J. J. Breen.

45. SAGINAW MACHINE GUN PLANT—*Contractor:* General Motors Corporation, 57th & Broadway, New York, N. Y. *Commanding Officer:* Maj. J. J. Breen.

46. MORGANTOWN ORDNANCE WORKS—Morgantown, W. Va. Ammonia plant. *Contractor:* E. I. du Pont de Nemours & Company, Wilmington, Del. *Commanding Officer:* Lieut. Col. John Huling, Jr.

New Plants, Works, Depots and Proving Ground—*Continued*

47. OHIO RIVER ORDNANCE WORKS—Henderson, Ky. Ammonia plant. *Contractor:* Allied Chemical Company (Solvay Process Company).

48. MUSCLE SHOALS—Ammonium nitrate plant. *Agency:* Tennessee Valley Authority.

49. KANKAKEE ORDNANCE WORKS—Joliet, Ill. TNT, DNT, and tetryl plant. *Contractor:* E. I. du Pont de Nemours & Company, Wilmington, Del. *Commanding Officer:* Lieut. Col. T. C. Gerber.

50. WELDON SPRING ORDNANCE WORKS—Weldon Spring, Mo. TNT and DNT plant. *Contractor:* Atlas Powder Company, Wilmington, Del. *Commanding Officer:* Capt. C. R. Dutton.

51. BAYTOWN ORDNANCE WORKS—Baytown, Tex. Toluol plant. *Contractor:* Humble Oil & Refining Company, Houston, Tex. *Commanding Officer:* Col. J. G. Booton.

52. PLUM BROOK ORDNANCE PLANT—Sandusky, Ohio. TNT and DNT plant. *Contractor:* Trojan Powder Company, Allentown, Pa. *Commanding Officer:* Capt. J. F. Rodenhauser.

53. ST. LOUIS ORDNANCE PLANT—St. Louis, Mo. Small-arms ammunition plant. *Contractor:* U. S. Cartridge Company, East Alton, Ill. *Commanding Officer:* Capt. D. L. Van Syckle.

54. DENVER ORDNANCE PLANT—Denver, Colo. Small-arms ammunition plant. *Contractor:* Remington Arms Company, Bridgeport, Conn. *Commanding Officer:* Lieut. Col. Duncan McGregor.

55. LAKE CITY ORDNANCE PLANT—Lake City, Mo. Small-arms ammunition plant. *Contractor:* Remington Arms Company, Bridgeport, Conn. *Commanding Officer:* Capt. W. L. Bell.

56. RADFORD ORDNANCE WORKS—Pepper, Va. Smokeless-powder plant. *Contractor:* Hercules Powder Company, Wilmington, Del. *Commanding Officer:* Lieut. Col. M. M. Serrem.

57. INDIANA ORDNANCE WORKS—Charlestown, Ind. Smokeless-powder plant. *Contractor:* E. I. du Pont de Nemours & Company, Wilmington, Del. *Commanding Officer:* Lieut. Col. R. E. Hardy.

58. ALABAMA ORDNANCE WORKS—Childersburg, Ala. Smokeless-powder plant. *Contractor:* E. I. du Pont de Nemours & Company, Wilmington, Del. *Commanding Officer:* Lieut. Col. James D. McIntyre.

59. RAVENNA ORDNANCE PLANT—Ravenna, Ohio. Shell-loading plant. *Contractor:* Atlas Powder Company, Wilmington, Del. *Commanding Officer:* Lieut. Col. R. S. Chavin.

60. KINGSBURY ORDNANCE PLANT—LaPorte, Ind. Shell-loading plant. *Contractor:* Todd & Brown, 9 Rockefeller Plaza, New York, N. Y. *Commanding Officer:* Maj. W. J. D'Espinosa.

61. ELWOOD ORDNANCE PLANT—Joliet, Ill. Shell-loading plant. *Contractor:* Sanderson & Porter, 52 William Street, New York, N. Y. *Commanding Officer:* Lieut. Col. T. C. Gerber.

62. IOWA ORDNANCE PLANT—Burlington, Iowa. Shell-loading plant. *Contractor:* Day & Zimmerman Company, Philadelphia, Pa. *Commanding Officer:* Maj. Otto M. Jank.

63. WOLF CREEK ORDNANCE PLANT—Milan, Tenn. Shell-loading plant. *Contractor:* Proctor & Gamble Defense Corporation, Cincinnati, Ohio. *Commanding Officer:* Capt. J. Horridge.

64. NEW RIVER ORDNANCE PLANT—Pulaski, Va. Bag-loading plant. *Contractor:* Hercules Powder Company, Wilmington, Del. *Commanding Officer:* Lieut. Col. M. M. Serrem.

65. HOOSIER ORDNANCE PLANT—Charlestown, Ind. Bag-loading plant. *Contractor:* Goodyear Engineering Corporation, Akron, Ohio. *Commanding Officer:* Lieut. Col. R. E. Hardy.

66. BAG LOADING PLANT—(*Location and contractor to be selected.*) *Commanding Officer:* Lieut. Col. James D. McIntyre.

67. GADSDEN ORDNANCE PLANT—Gadsden, Ala. Shell-forging and machining plant. *Contractor:* Lansdowne Steel & Iron Company, Morton, Pa. *Commanding Officer:* Capt. J. S. Walker.

68. DETROIT ORDNANCE PLANT—Detroit, Mich. Tank-manufacturing plant. *Contractor:* Chrysler Corporation, Detroit, Mich. *Commanding Officer:* Lieut. Col. H. W. Rehm.

69. GUN TUBE PLANT—Homestead, Pa. *Contractor:* Mesta Machine Company, P.O. Box 1466, Pittsburgh, Pa. *Jurisdiction:* Pittsburgh Ordnance District.

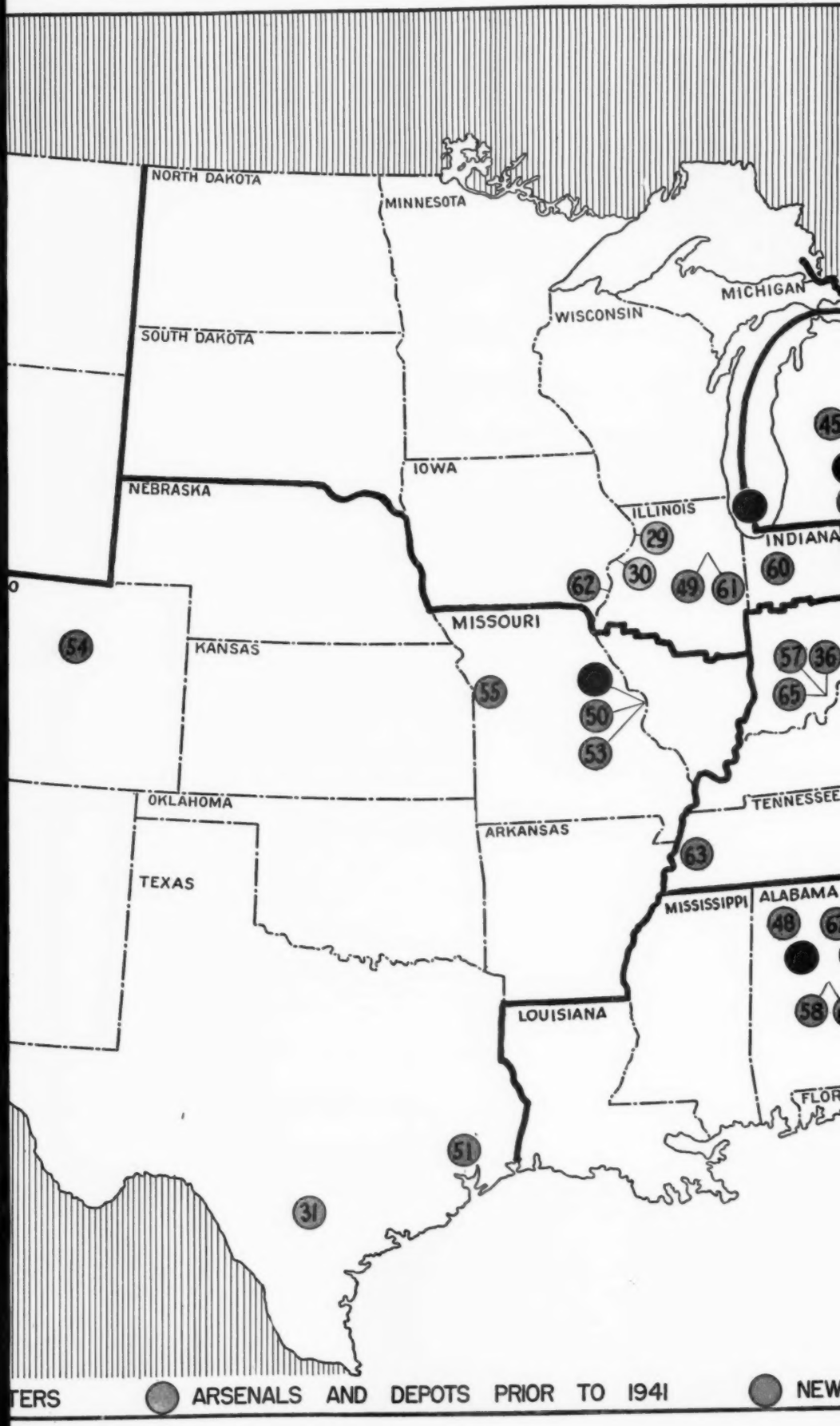
70. ARMOR PLATE PLANT—Philadelphia, Pa. *Contractor:* Henry Disston & Sons, Inc., Philadelphia, Pa. *Jurisdiction:* Philadelphia Ordnance District.

The Ordnance Establishment for Military A

Explanatory Data with Reference to Each Place Are Given under

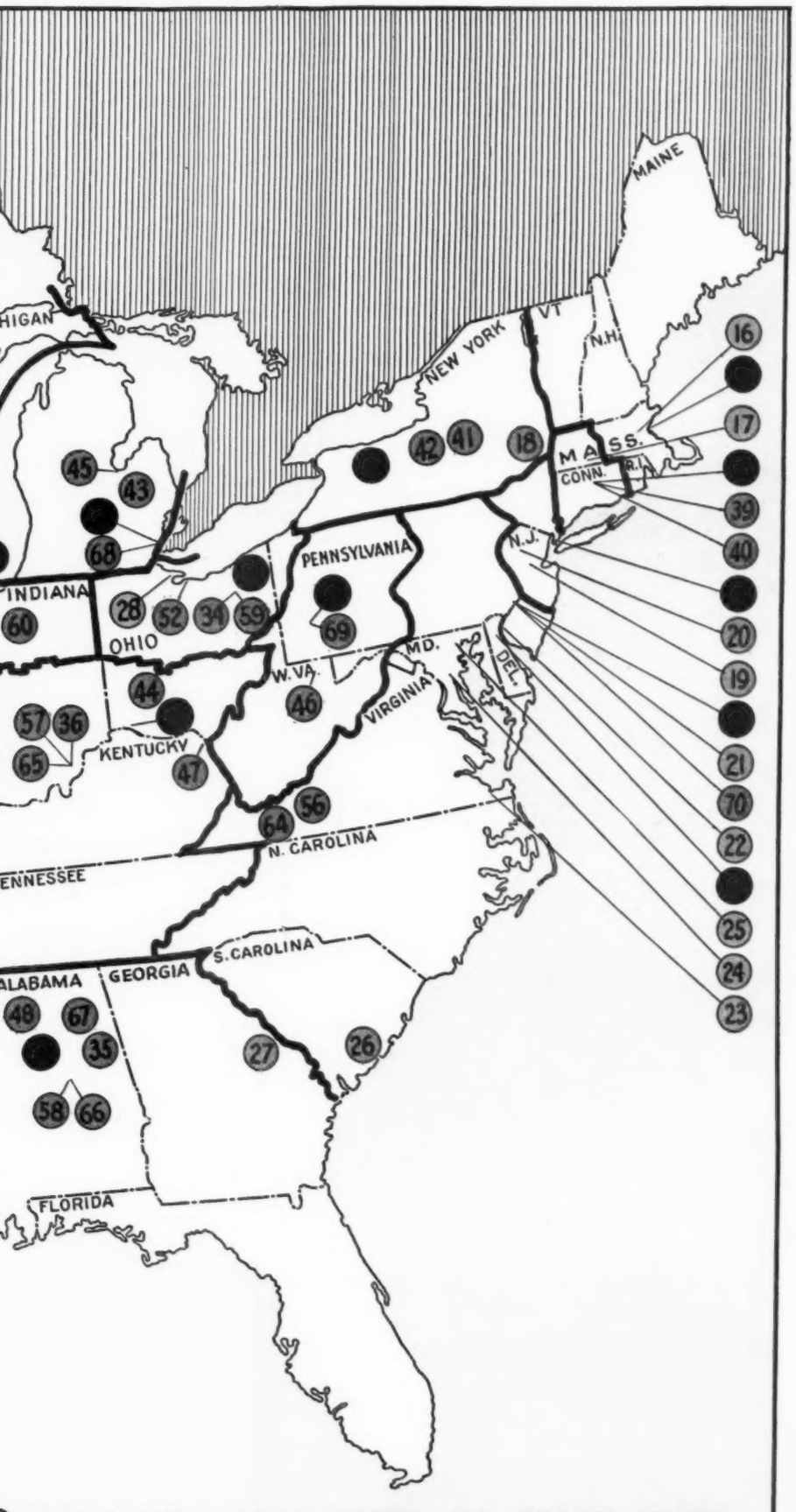
nance Establishment for Military Armament Production and Su

a with Reference to Each Place Are Given under the Corresponding Numbers on Pages



and Supply

on Pages 466 to 468.



NEW PLANTS, WORKS, DEPOTS AND PROVING GROUND

U. OF MICH.

Forging High-Explosive Shell

Current Technique in Mass Production

Arthur F. Macconochie*

WHAT is the best way to manufacture high-explosive shell? This problem, which had its inception in the fertile brain of that master mind of the Renaissance, Leonardo da Vinci, has not yet been solved, inasmuch as there is still no general agreement on a single solution. Among the reasons for this are the fact that shell can be made successfully by a number of different methods; further, the shell itself is the product of essential compromises amongst a number of partially conflicting considerations. From the standpoint of the user—the artillery or the infantry, as the case may be—the shell must be safe to handle, accurate in flight, and of maximum efficiency at the target. The steel manufacturer desires as much latitude as possible in his specifications in order to avoid lost heats. The forger demands sound billets which are easy to forge, with the largest tolerances and the greatest permissible amount of excess metal in the carcass. The machiner calls for forgings which are uniform as to dimensions and hardness, easy to machine, and with a minimum of metal to be removed.

The earliest known drawing of a high-explosive shell exhibited a spherical jointed container made of some material like leather, the parts being sewed together. The reference is contained in Da Vinci's manuscript preserved in the Ambrosian Library, Milan, Italy, and includes a sketch of two mortars discharging explosive shells and shrapnel. It is not generally known that among the many other achievements of this extraordinary genius were proposals for built-up wire-wound guns, breechloaders, rapid-fire guns and machine guns, tanks, submarines, and the possibilities of gas in warfare. Beyond the small and relatively ineffective gun of his day, with its round, ill-fitting projectile, he projected a broad field of ordnance, hitherto unexplored. Indeed, as William B. Parsons has pointed out in his delightful book, "Engineers and Engineering in the Renaissance," Da Vinci's keen constructive imagination carried him far in advance of the artillery of the Napoleonic wars, suggesting in fact the practice of 1914-1918 rather than that of the early part of the nineteenth century.

For more than three hundred years after the Renaissance little progress was made in the art of manufacturing high-explosive shell. This is attested by reference to the course of instruction in gunnery offered to cadets of the United States Military Academy by Bvt. Col. James Gilchrist Benton, instructor in ordnance and the science of gunnery, who wrote his well-known text published in 1867. There, the relative advantages and disadvantages of stone as a material of construction are discussed, the author noting its want of density and tenacity, but observing that when the English fleet under Admiral Duckworth forced the passage of the Dardanelles in 1807, a stone ball weighing 800 pounds struck and nearly destroyed the English admiral's ship. Lead, wrought iron, cast iron, and compound projectiles are also considered; but steel had made its appearance, and with the advent of the Bessemer process it tended to displace all other materials from the field.

*Professor of mechanical engineering, University of Virginia, Charlottesville, Va. Member, Shell Forging Committee, American Society of Mechanical Engineers.

As long as shot were round, the task of forging hollow shell from steel or wrought iron was exceedingly difficult if not virtually impossible; hence the early use of hollow cast-iron shell. However, with the appearance of the rifled cannon with its elongated projectile, toward the middle of last century, the problems of the forger were simplified, and from that time to the present, shell which have to withstand high powder-chamber pressures have been forged from the billet or the rolled bar. To the layman, the somewhat complicated series of operations now considered necessary to produce a shell seemingly might be simplified by some form of casting procedure, but no method so far developed appears to give quite the same effective guarantee of strength and soundness as the forge. Not only must the shell be capable of resisting set-up in the gun, but the base especially must be proof against penetration by high-pressure propellent gas.

During the last war it was customary to hold down the sulphur content of shell steel to very low percentages, but today for 75- to 155-mm. shell (with one exception) we are using in this country high sulphur-manganese steels with yield points running from forty to sixty thousand. Our neighbors across the border to the north prefer a somewhat higher carbon content of around 0.52 with about 0.82 manganese. The well-known effect of sulphur in steel when present in quantities above the usual small amounts is to produce a fibrous structure resulting in free-machining properties. Experiments conducted as far back as twenty-five years ago show that sulphur, when accompanied by a sufficient amount of manganese, is not such an undesirable constituent as it formerly was supposed to be. In fact, the effect of this element upon the tenacity and ductility of steel, at least up to 0.1 per cent is so slight that it may be disregarded. If allowed to occur in the form of ferrous sulphide, FeS, much harm will result, the steel being "red-short," but when neutralized with a sufficient amount of manganese, it may be comparatively harmless even when present in amounts in excess of 0.1 per cent.

The reason for this peculiar behavior of sulphur lies in its marked tendency to form continuous envelopes of FeS around each grain of pearlite. Since these sulphide films fuse at a red heat, the continuity of the metal is interrupted and the steel is said to be "hot short." Manganese sulphide, on the other hand, instead of forming envelopes about the crystalline grains of the metal segregates into globules at temperatures near that of the metal on solidifying, upon which the main body of the metal then contracts. Since manganese sulphide has a much higher fusion point than ferrous sulphide, it does not melt at forging heat but becomes plastic like the main body of the metal. In this form it rolls out into fibers, giving the metal almost the appearance of wrought iron, when present in sufficient quantity. This is the explanation of the fibrous structure of high sulphur-manganese steels, to which we attribute their free-machining properties. To get the best results there should be about three times as much manganese as that actually necessary for the formation of the sulphide, or approximately five times as much manganese as sulphur.

FIG. 1. RADIOGRAPH TORCH FOR CUTTING BILLETS

During the World War, forging operations on 75-mm. shell were conducted somewhat as follows: The shell steel came from the plant in bars about 10 feet long and 3½ inches in diameter and were marked with a heat number stamped on them at the mill. This heat number was retained throughout all subsequent operations, being stamped on the forgings before they were sent to the machine shops. The steel used was known as class B, made by the basic open-hearth process, and contained a maximum sulphur and phosphorus percentage of 0.06. Breaking was carried out by first nicking the bar with the oxyacetylene torch and then applying an alligator shear. Thereafter, inspection was carried out as the billets rolled down a slight incline. Furnace temperatures during the heating operation ranged around 2,200 to 2,400 degrees with billet temperatures of 1,800 to 2,200 degrees.

FORGING of the billet was carried out under the hydraulic press in three operations. The first of these was the familiar pierce; the second, a setting-down operation in which the forming punch entered the billet which was mounted in a shallow die and in which the thickness of the base was fixed; the third, a draw through two dies. In the pierce, the billet, which was about nine inches long, was extruded past the punch to some extent, producing an elongation of about three inches. The die was water-cooled by means of a spiral channel and was capped by a "pilot" or guide for the punch to insure proper centering. Centering always has been and still remains something of a problem. It is closely associated with even heating, since no mechanical device is completely effective in securing concentricity of the forged carcass if one side of the billet is hotter than the other. The pilot was mounted and removed by hand.

The arrangements for the pierce (at least in one system) were further complicated by a spring yoke operating on a pin passing through the bottom of the die which pushed the billet up into a cylindrical neck in the pilot, thus centering it for piercing. As the punch descended it pushed the billet to the bottom of the pot, forcing the ejector pin down against the tension of the springs in the yoke, until the head of the pin seated in a recess provided for it in the bottom of the die. From this point on, the action proceeded precisely as though the pot were solid. Another feature of some interest was the arrangement whereby 3 screws, placed at 120 degrees, were used to secure alignment of the pot. If thick and thin cups appeared, suitable adjustments could be made. On the upward stroke of the punch, the ejector pin functioned if the forging failed to stick to the punch. A familiar arrangement of stripper jaws removed the forging from the punch. Cooling of the punch was effected by inserting a pipe carrying water into a ¾-inch hole in the center.

By comparison with the practice of the World War, our methods today are characterized by improved techniques, some of which are radical departures from long-established practice. The general trend is in the direction of reduction of man-hours by way of metallurgical control—superior forging practice resulting in weight reduction of the carcass, finish forging of the cavity, and greater ease in machining. As far as the high-capacity projectile required in such vast quantities by the Ordnance Department is concerned, elimination of heat treatment has contributed largely to this end. Generally speaking, the first phase to be considered is that of steel production and the suitability of the product for the specialized processes involved in shell forging. This is controlled at the mill by means of the usual chemical analysis, physical tests, visual inspection and the etching of specimens from the ingot, bloom, and bar. The practice of the National Steel Car Corporation, Hamilton, Canada, for instance, calls for hot-top casting, and the specifications designate cropping

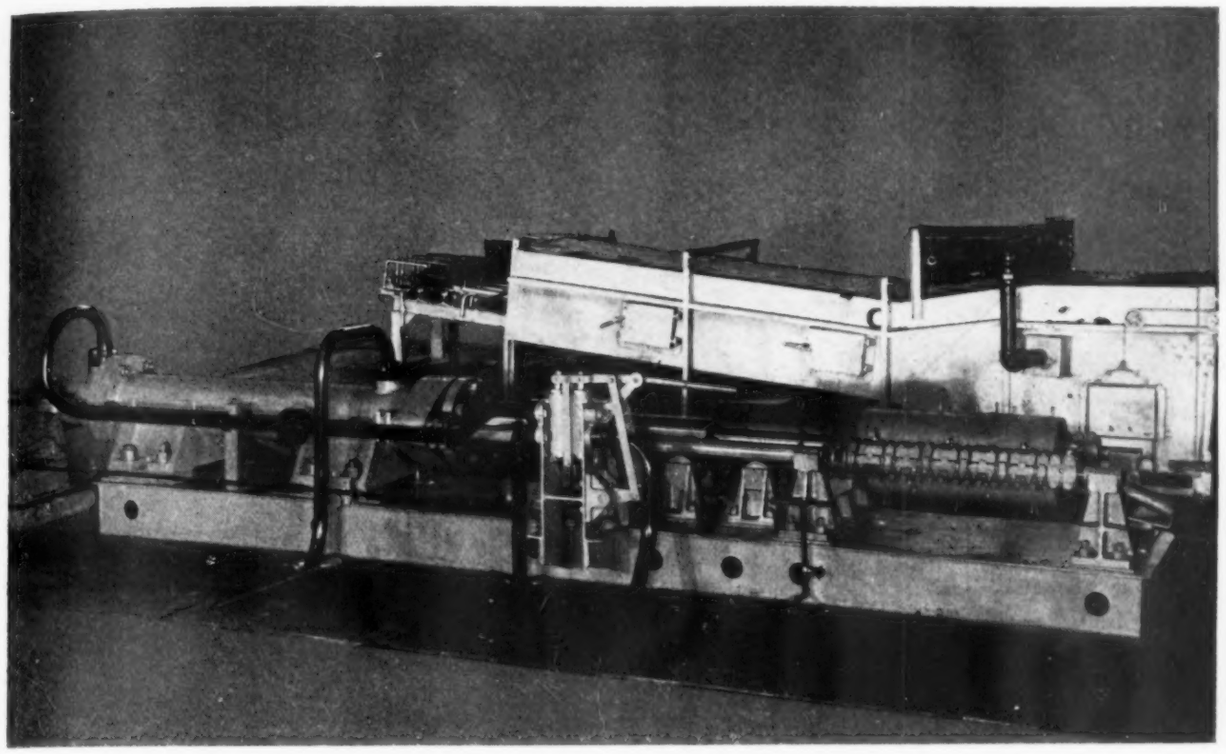


FIG. 2. HYDRAULIC ROLLER-TYPE DRAW BENCH—HEATING FURNACE IN BACKGROUND

at least 25 per cent from the top of the ingot and 5 per cent from the bottom. "Big-end-up" pouring is commonly supposed to give a better guarantee of the absence of "secondary piping." The bars rolled from these ingots are of beveled edge square section, the diagonal dimension corresponding to the inside of the die pot. The purchase order specifies the length of the bars, these being multiples of the billet. The heat and ingot number are stamped on each bar for identification, this being carried through all marking operations to the finished shell.

Again by way of contrast with the more laborious nicking and breaking operations familiar enough in the last war, this same company employs an "Airco" No. 4 radiograph cutting torch which cuts off the billets very clean and square (Fig. 1). In action, a complete ingot consisting of approximately ten bars is placed on the roller cutting table, all bars being advanced to a gauge. The machine then runs at right angles to the axes of the bars in parallel tracks made from structural channel mounted on the cutting table directly above the bars. Preheating of the bars is necessary where the bevel edges of the bars touch each other. In the case of the 3.45-inch shell, a 3½-inch square section is used and a cutting speed of approximately 7 inches per minute is obtained. Thus the number of billets obtained from 1 machine per 8-hour shift, with 1 operator and 1 helper, averages 432, with a total cost for materials and labor of $4.90 for 100 billets.

CONSIDERABLE improvement over the practice of twenty-five years ago also may be noted in the arrangements for heating billets. Among the ends in view are uniformity of forging temperature, the production of a scale which can be removed easily (since we cannot practically prevent the formation of scale), the prevention of decarburization, and, last but not least, lowered costs. As already pointed out, the success of the forging operation depends in large measure on the efficiency of the heating operation, hence the trend toward the rotary hearth. In a familiar design of rotary hearth, the fuel used is producer gas having a calorific value of 530 B.T.U. per cubic foot. Proportioning valves used to control the mixture of gas and air are located in three zones, the first zone being set at 1,900 degrees, the second at 2,000, and the third at 2,150 degrees—the maximum permissible "thermal head" being 2,192 degrees. The first and second zones have indicating and controlling potentiometers while the third, in addition to these features, has a temperature recorder.

The hearth of the furnace consists of a rotating ring supported on double trunnions—a friction drive being employed to revolve the hearth by means of a roller-chain drive through a reducer unit and a small electric motor. The furnace itself is built of heavy welded steel plate reënforced with structural steel members, the heating chamber being lined with 9-inch first-quality firebrick backed with 4½-inch insulating brick. There is a full-arch construction with burners firing from both sides and vented at hearth level by ducts carried up the inner and outer walls. Between the loading and unloading doors there is a dividing arch sufficiently high to allow billets standing on end to pass underneath. To the left of the unloading door there is a burner whose hot gases are diverted across the opening below the arch to prevent heat absorption by fresh billet charges from affecting those in the soaking zone. Loading and unloading doors are operated by foot-controlled air operating valves, billets being loaded and unloaded by means of tongs suspended on overhead trolleys. Three operators are required—one for loading the furnace, a second for unloading from furnace to floor and a third for descaling the billets. In normal operation, 100 pounds of steel require 330 cubic feet of gas.

Perhaps the greatest divergence from former practice is in the forging operation itself. Whereas the pierce (with some

extrusion) and the draw through solid ring dies were formerly universal, recent developments, while retaining the pierce, tend to avoid extrusion by the use of a square-section billet which opens out into the die. Further, the drawing operation exhibits such newcomers in the field as the roller-type draw bench and the Witter cross roll, the latter an adaptation of the much older Mannesmann principle of making tubes. Then, too, the mechanical forging machine, which completes the forging from the billet in a series of five or six operations, is making important contributions to the development of modern forging practice.

The roller draw bench (Fig. 2) employs five sets of reducing rolls, each set consisting of three radially arranged rollers mounted in bronze bushings and housed in a circular steel casting. Power is applied by a 50-ton single-cylinder hydraulic press operating on a pressure of 1,700 pounds per square inch. In action, the pierced billet, after being removed from the preceding piercing operation and being subjected to a slight reheat, is transferred to a V-shaped locating block directly in front of the finishing punch. The latter is carried in a close-fitting sleeve which forms the extension of the hydraulic plunger of the press. The control valve is then opened and the punch advanced until it enters and bottoms on the forged cavity in the carcass. Continuing at uniform speed, the punch pushes the forging through the five sets of reducing rolls in succession, emerging through stripping bars which remove the forging from the punch, permitting it to drop on to a receiving apron. The punch lubricant employed consists of one part of graphite and five parts of quenching oil. The capital cost of this unit, including the piercing press, draw bench and furnace, is about $45,000, and its production rate is around 100 shells per hour.

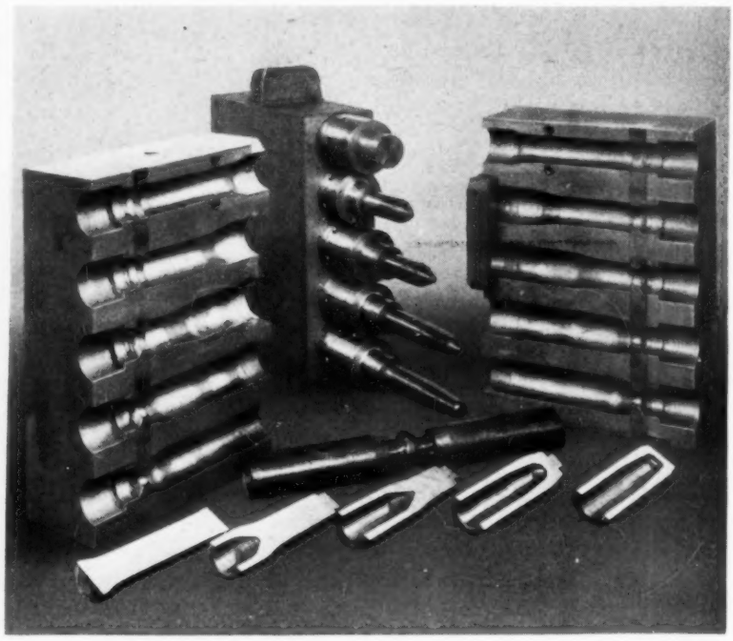


FIG. 3. DIES AND TOOLS FOR FORGING 75-MM. SHELL

SOME idea of the advance in forging practice may be gained from a study of the limits and tolerances laid down by the Ordnance Department for certain types of forged shell bodies, as follows:

	O.D.		*I.D.*		*Permitted Eccentricity*
75-mm.	3.28	—.06	2.13	.02	.0625
90-mm.	3.92	—.08	2.70	.02	.0625
105-mm.	4.52	—.08	2.91	.02	.0625
155-mm.	6.60	—.10	4.85	.02	.093

The "permitted eccentricity" means the difference in wall thickness. It should be remarked, however, that these dimensions are not mandatory except where the Government buys forgings and supplies these to one or more machining contractors. The practical effect of this policy is that shell machiners who procure their own forgings may, by mutual arrangements with the forging manufacturer, depart from the forging drawings of the Department; thus, if a forger wants to add or subtract metal from the forging he may do so provided the machiner turns out a satisfactory shell. Presumably, however, if the cavity is forge-finished (and this practice appears to be meeting with universal acceptance) the forger must conform to internal dimensions and form but may depart from the prescribed limits of outside diameter.

Broadly speaking, we might divide forging procedures into two categories: The first, in which the metal is redisposed by the exercise of great pressure by a punch and a series of suitably formed dies, as exemplified by the mechanical forging machine; and the second, in which the billet is first opened up or "pierced" by hydraulic or mechanical pressure and subsequently drawn or rolled to form by means of dies or rolls. The so-called "1-shot" method, to which detailed reference cannot be made at this time in deference to the wishes of the Canadian Government, is virtually in a class by itself but falls more nearly within the second category than the first.

The principal claim in favor of this method advanced by the manufacturer of one well-known forging machine revolves about the presence in shell made by the pierce-and-draw method of a cone of shear weakness in the bottom of the carcass and its absence from shell bodies produced by the operation sequence of the mechanical forging machine. In the forging machine, the billet is gradually opened up after the initial "upset" by a wedge-like action with a series of pointed punches, final form being attained by flexure of the body wall on entry of the forming punch. The piercing punch, it is averred, carries before it a cone of metal which descends to the base of the shell, much after the fashion of a snowplow driving through a drift. If this be true, it is rather a serious indictment of all pierce-and-draw methods. However, revisions which were made to forging drawings of the Ordnance Department last spring substituted cavities with hemispherical ends (except in the case of the 3-inch antiaircraft shell) for the older form which required a more snub-nosed forming punch. It is reasonable to suppose that basal weakness, porosity, etc., result more often from poor metal in the center of the billet or the presence of scale than from faulty distribution of metal during the forging operation.

The principles of the mechanical forging machine can be well understood by reference to Figure 3, which shows the dies and tools used for producing 75-mm. high-explosive shell. The dies are mounted in a very heavy frame which

admits of parallel movement of the half die. In action, the dies open to admit the hot billet, then close upon it before the advance of the punch. This process is repeated in each operation. In practice, two carcasses are forged on one bar, one end being heated for forging while the other is used as a tong. After one end is formed, the other is heated and the process repeated.

There seems little question, despite reports of large scrap percentages from forging-machine operations, that the forging machine, when properly designed and the requisite care given to tool design, can turn out a highly acceptable forging. The life of the tools, because of the short period of contact between the punch and the forging, is likely to be long, and there is an absence of relative movement between the forging and the die. Capital costs on forging machines capable of handling 75-mm. and larger-caliber shell run upward from $52,000. They have a time cycle of about 30 seconds or better on 75-mm. carcasses, and their production rate when well handled runs from 80 to 100 forgings per hour, though it may be as low as 65 to 70. A crew of six or seven men is required. This includes the operator, heaters, a man to swab the piercers with hot die lubricant after each forging is made and to direct cooling water on the piercers after the swabbing in order to get good tool life, and a man to handle the forging from the machine to the air-cooling blast. The last-mentioned operation may be necessary to obtain specified hardness of the forging without subsequent heating and quenching.

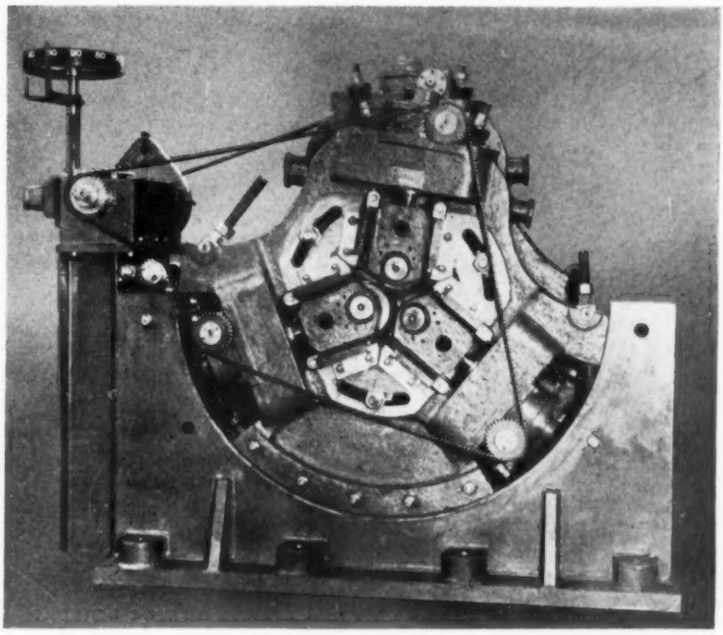


FIG. 4. END VIEW OF CROSS-ROLL MILL

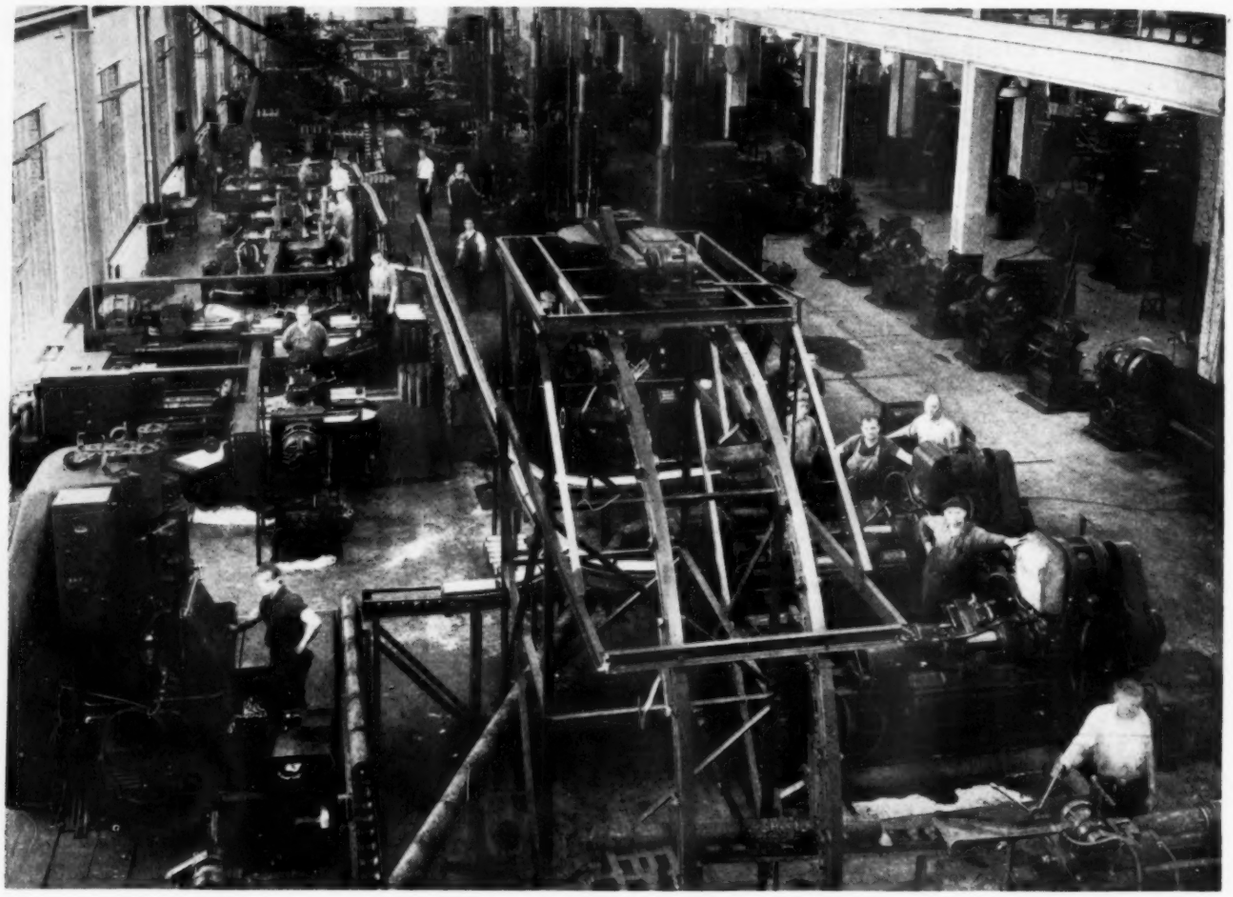
As regards the use of hydraulic power for the piercing operation prior to drawing on a horizontal draw bench, at least 150-ton capacity must be provided for the 75-mm. shell; for the 105-mm., 300 tons; and for the 155-mm., 500 tons. Capital costs range from about $6,000 for the 150-ton press to around $13,500 for the 500-ton. To this must be added about $8,000 for a draw bench suited to 75-mm. shell, up to $14,000 for a draw bench adapted to 155-mm. shell. If the hydraulic accumulator and electric pump are not on hand, a further investment of perhaps $20,000 must be made. Productive capacity of the equipment runs close to 100 shells an hour.

In the Baldwin-Omes shell-forging machine, the operating principles of the upsetter described above are combined with those of the draw bench in such a way as to reduce the total number of operations to two (as in the hydraulic pierce and draw). It is, in fact, a mechanically operated press possessing certain interesting features, notably the ability to perform these two operations simultaneously (on different forgings, of course), at least as far as the smaller sizes of this machine are concerned. In the larger designs, the pierce is separated from the draw. The machine operates as follows: Briefly, a heated square-section billet is inserted in a split die while open, the billet resting on the lower surface of the die, which is split, as it were, diagonally. After the closing of the die, a piercing mandrel, operated from the crankshaft, enters the hot square-section billet and expands the metal toward the walls of the die, a slight extrusion past the punch and consequent lengthening of the billet taking place. Thereafter the pierced forging is placed on the drawing mandrel and finished complete on the inside and with a minimum of metal on the outside for machining off. In order to increase the capacity of the smaller machines, a number of piercing mandrels and dies are provided so that each piercing mandrel and drawing mandrel can be used in rotation. These mandrels are best made from a tungsten-nickel alloy steel—containing about 4 to 5 per cent of each alloy. When high (14 per cent) tungsten steel is used, the mandrels themselves do not appear to stand water cooling very well.

The time cycle on the Baldwin-Omes machine is stated to be fifteen or sixteen seconds. This would give a maximum of 240 forgings an hour. In actual practice the rate is considerably less—perhaps between 150 and 180. The initial investment in the case of the so-called medium-sized machine is about $70,000, while the large unit, capable of handling up to the 155-mm., costs around $120,000. The medium-sized machine requires four or five men to operate it while the larger unit needs six for efficient production.

ONE of the more spectacular advances in the art of forging high-explosive shell is known as the Witter cross roll. Since this process is related fundamentally to the very ingenious and original method of rolling seamless tubes, developed many years ago by Mannesmann of Remscheid, it may be well to introduce this brief account by a reference to the principles involved in the Mannesmann tube-making machine. Essentially this consists of a pair of conical rolls—or to be more precise, frustra of cones—with their axes set at a slight angle. In action, a solid cylindrical block of steel is raised to a high heat and passed through the rolls in a direction which might be described as that of a median axis. The rolls rotate with considerable velocity, causing the billet to revolve and at the same time imparting to it a forward motion in the direction of the larger ends of the rolls.To prevent the work from being forced out laterally, at least three rolls are necessary, two of which are the working rolls and the third merely a pressure or guide roll.

By way of offering at least a partial explanation of this



One of the Tests Which Artillery Shell Forgings Must Meet—The Shell-Machining Plant at Frankford Arsenal

interesting process, we note that if the diameter of the billet were equal to the least distance between the rolls, nothing would happen; in other words, the steel block would simply pass through the rolls unaltered. If, however, the diameter of the billet exceeds this dimension, the block is seized by the rolls and caused to rotate with a helical or screw-like motion. As the diameter of the rolls constantly increases from the point where the distance between them is least, there is a tendency to impart an increasing velocity to the outer surface of the steel billet which in consequence is drawn out at a more rapid rate than the interior, the net result being a tube. It is even possible to produce a tube with closed ends by this method. The process as just described is incomplete inasmuch as it is extremely difficult to obtain tubes exactly of the thickness desired and with a smooth interior. It was therefore found necessary to roll out the tube over a conical mandrel which rotated with the tube as it was formed.

In the Assel mill, recently adapted to the rolling of closed-end tubes (shell), the simple conical frustra of the Mannesmann mill are replaced by a more complicated form including a cylindrical portion and a conical portion with a "hump" between them. The action of the mill is such that the pierced blank on entering the mill is rolled over a mandrel, the rolling being done by means of three "hump" rolls as shown in the end view of the mill (Fig. 4). Each roll is separately adjusted as to relative angle to the other rolls and because of the hump provided in the rolls, the lead end of the pierced blank centers itself and rolls easily as the mandrel is forced through the mill. The mill is driven by means of a motor running through a speed reducer which in turn drives the actual rolls through three shafts. The arrangement provides for variation of roll angle and distance between the rolls.

From all accounts, this Witter cross-roll mill has much to recommend it. It is fast; according to figures offered in this connection it would appear to be able to roll 240 blanks an hour. In the matter of weight reduction it also compares well; instead of the 22-pound billets commonly acceptable in the case of 75-mm. shell, the mill will deliver 16-pound billets. For the 105-mm. shell we have 37 pounds as against 53 pounds. The equipment layout embodying the cross-roll mill, includes one mechanical press capable of piercing two hundred and forty 75-mm. blanks an hour. The total investment in these two items, including the electrical equipment, is around $75,000, with delivery dates fourteen to sixteen weeks from receipt of order.

Editor's Note: Closely allied to the problem of shell forging is the corollary problem of shell machining. In subsequent issues, Army Ordnance plans to present informative articles on the principles and current practices in this important field. Several authoritative articles on the general subject of field-artillery ammunition production have appeared in recent issues of Army Ordnance. Especially noteworthy are the articles by Brig. Gen. L. H. Campbell, Jr., on "Artillery Ammunition Production" (Vol. XIX, No. 113, March-April 1939, p. 273) and "Cartridge Case Manufacture" by the same author (Vol. XX, No. 118, January-February 1940, p. 239). Particularly connected to the general subject is the article "Military High Explosives," by Capt. Carl R. Dutton (Vol. XX, No. 120, May-June 1940, p. 389).

Synchronized Arms Production

Management Methods Must Augment The Machines

Sanford E. Thompson*

IN OUR preparation for defense, experience in the World War forms the background for present action. Causes of the delays in shipment of armament to the A.E.F. in 1918 require most careful analysis to see whether we are profiting by these failures in order to avoid repetition.

Cables to the A.E.F. in France during the war, which passed over my desk in Washington, carried continual corrections—always backward—in expected shipment dates and in quantities to be shipped. In early January 1918, for example, the plants making 75-mm. guns estimated that 532 of those on order would be completed by April. A total of 212—less than half—were produced at that date. Of these, only eighty-five were completely finished. But none of these eighty-five guns was shipped to France in April. In fact, out of orders for 10,000, only 143 were shipped before the Armistice in November. Discrepancies like these between promises and performance occurred in almost all classes of matériel.

Of 8-inch seacoast guns and railway mounts, 18 of these were expected by June 1918, and only 1 was complete on that date; of 4.7-inch guns and carriages, 150 were expected and 24 were ready; of 155-mm. howitzers and carriages, 135 were expected by June and none were ready because no recuperators would be available until July. Other shipments were held up by lack of sights, limbers, and firing platforms. Two million shells were ready for shipment in October 1918, but all were held up because they lacked adapters and boosters.

We equipped our overseas troops with rifles, and we furnished our Allies with explosives. Except for these, the only reason our forces in France were able to operate at all was due entirely to the use of artillery made by England and France.

ANALYSIS of our World War records points clearly to two specific causes for the delays in shipments to Europe, both of them tracing back to management—management in private industry, management of the railroads, management of government: (1) Lack of synchronization of production, by the Government departments, of the various items and parts and components entering into a complete unit; (2) Inability of the manufacturer to estimate the time required to produce and failure to produce on time.

The deficiencies were augmented by congestion on the railroads due, not only to shortage of rolling stock, but also in a measure to insufficient planning of priority of shipments of raw and partly finished materials.

Except for transportation, which is in far better shape now, the same causes for delays are showing up already in our defense program, fulfillment of which is as vitally important as it was in 1918. Delivery of airplanes is far behind schedule due to lack of components. It is evident that concentration on solution of management problems is the greatest need today.

Synchronization of deliveries involves not merely the keeping track, by the War and Navy Departments, of promises and deliveries; it involves factory operation of the highest modern type in order that the critical components may be ready for delivery on time.

The complications and the detailed problems to be solved in 1917-1918 were tremendous, and today they are similar both in procurement and production. A single shell for the 75-mm. gun so urgently needed in France in 1918 consisted of sixty-three parts. Each had to be manufactured separately. Many of the parts came from different plants in various sections of the country. Every one was necessary for completion of the shell. Materials used in the making of such a shell included steel, copper, lead, tin, brass, bronze, felt cardboard, paper, calico, and tinfoil in addition to the explosive. Shortages of adapters and boosters also were two of the sorest points.

Manufacture of the 75-mm. American model 1916 field gun required gun forgings from three plants, heat treatment for one of them from another plant, machining from four other plants, and carriages with recuperators from still others. Moreover, a battery of field guns was composed, in 1918, of four guns with carriages, having three caissons and caisson limbers to each gun, one 2-horse wire reel to each battery for providing communication with the fire control, one 6-horse reel and cart for each brigade headquarters, supplemented by battery wagons with their forge limbers and store wagons and the necessary fire control. Yet we think of the 75-mm. gun as a single item of equipment! Under such conditions one poorly managed plant could and did hold up entire shipments of armament.

Airplanes are sometimes thought of as being produced in a single factory, but, in addition to the airplane itself, parts of which usually are built in different factories and assembled at the aircraft plant, there are a multitude of accessories embracing propellers, shock absorbers, stabilizers, starters, tires, wheels, brakes, windshields, landing gear, batteries, lights, radio, parachutes, safety belts, oxygen-supply equipment, clothing, and goggles. Most of these items are built in different factories. All are essential, and an airplane is not ready for flight until they are provided. A deficiency in any one item holds up the final use of the airplane.

MANAGEMENT correlation centers in the various branches of the Government. There is apt to be too great reliance on manufacturers' promises. Many of the manufacturers, sweating blood to make deliveries, do not know the real causes for their own broken promises. They need help more than criticism.

A vital need in the present emergency, after the placing of procurement contracts, is the recording of production in the manufacturing plants through systematic progress reports of general uniformity in design and the presentation of the data to show relative progress of different components of a complete item. Thorough analysis of these data by the Government is also necessary to find the bottlenecks, and then, most important of all, the items should be followed up by checking at the plants.

A common fault has been concentration on fulfillment of

*Former Lieutenant Colonel, Ordnance Department, U. S. Army, 1918.

contract dates of delivery instead of on requirements based on *use*. Time and effort and most valuable production facilities may be absolutely wasted by hastening production of a component which cannot be used for months because of shortage of another component required to make up the complete unit.

There must be, therefore, not merely a check on monthly delivery versus contract requirement, but, far more important, as I have noted above, the records must be maintained in such a way as to show relative progress of every component making up a complete unit. It may involve, in many cases, holding back production of certain items that are not needed on contract dates to give precedence to other items that are essential to complete unit correlation. It even may mean giving priority to commercial products where certain parts of matériel cannot be utilized immediately. For example, if shells cannot be completed on time for lack of adapters and boosters or explosives, it is worse than useless to make up the casings far ahead of time and store them for future use.

Orders, both for raw materials and manufacture, moreover, involve correlation not only within one department, but also among the Army, Navy, and other departments of the Government. Reports on progress of subcontractors are as necessary as, perhaps more necessary than, reports on the work in the main plant.

BUT progress records and reports count for little unless the management in the factory as well as in the Government organization is capable of meeting the critical requirements.

Recalling visits to various plants and arsenals in December 1917, made at the request of the Chief of Ordnance, I found delays due to a great variety of causes, but all harking back to deficient management. The causes comprised such matters as the following: changes in design, priority conflicts between departments, delays in ordering parts, lack of required raw material, handicaps of new equipment, slowness of subcontractors, lack or too great nicety of inspection standards, antiquated plant methods, poor methods of estimating and accounting, defective work, faulty liaison with Washington, poor planning of production with disregard of choke-points in the plant, shortage of labor, transportation delays, and lack of fuel. Many of these defects already are showing up in the operation of our defense program.

Management in government involves prompt decisions, with politics eliminated; well-regulated priority requirements in raw materials and in scheduling production; skilled Government inspectors in the plants; follow-up of individual orders to synchronize time of final assembly, and assistance to manufacturers in meeting schedules.

Management in the industrial plant involves acceptance of orders with assurance that delivery dates can be met; knowledge of the capacity of every department and piece of equipment, and maintenance of inventories. It involves knowledge of the time required to replenish raw materials or manufactured parts and knowledge of standard times required for every machine and work place. Good management also requires planning of manufacturing orders sent to the shop, based on advance knowledge of the capacity of each department and of each essential machine; entering these orders in the shop in the sequence and volume that will insure progress on scheduled time, and the maintenance of production records that keep both plant executives and the Government officers constantly informed of status of progress. Establishment of measures of productivity for the workers and maintenance of quality through planned inspection methods also are necessary as well as gaining the thorough interest of the workers in doing every job quickly and well. The accomplishment of these things requires an organization of executives experienced in management methods and in labor relations.

It might seem that all these are obvious requirements of government and industry. True, but they are all essentials in production which are vital in our defense program and so often woefully neglected.

THE problem is, first, for the Government officials to find the places where acceleration is needed and, secondly, for the manufacturers to speed their production, especially on the key items which will advance the program as a whole.

Experience both in industry and in war has shown conclusively that productivity in individual plants such as those receiving contracts for matériel can be increased at least twenty per cent on an average by improvement in management methods and without additional equipment. Experience also has shown that final delivery of complete units can be expedited to even a greater degree through synchronization of production of all components entering into a complete unit.

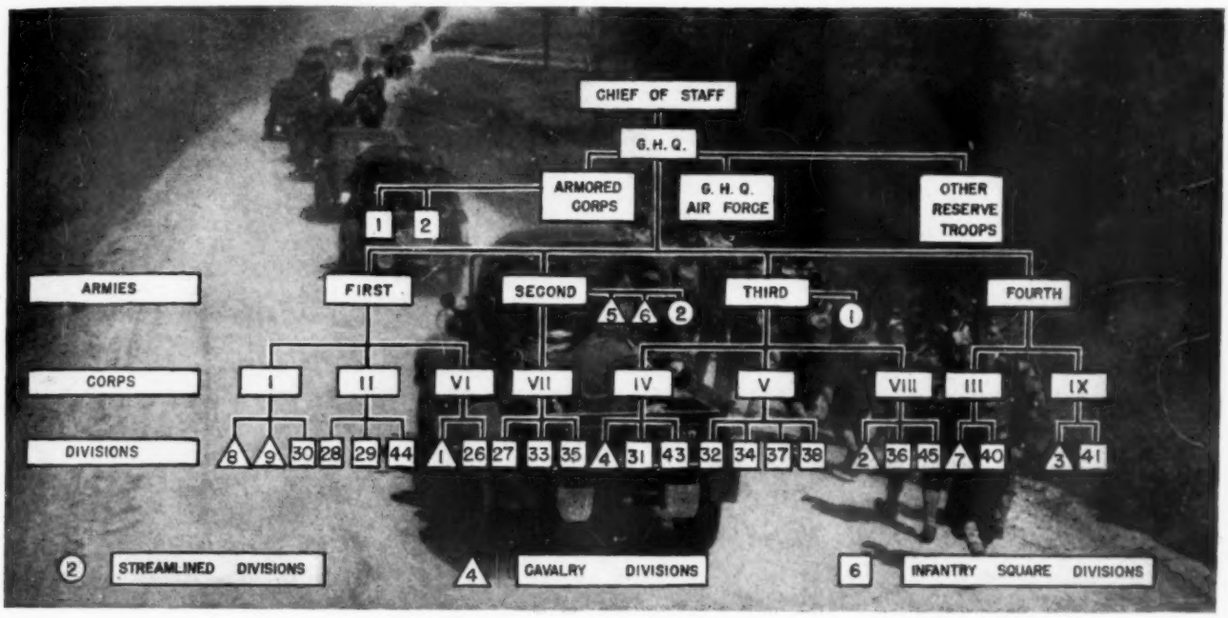
Each plant presents a special problem since no two are alike; nor can a universal "system" be adopted to fit all cases. In our present emergency, short cuts are necessary; for example, elementary time studies usually take too long, and financial incentives to workmen are often impracticable because of the variety of parts to be made. Standardization is vital but must often be approximate. "Ritual" must be avoided. Improvement must be in terms of modification of present methods to correct specific defects without upheaval of personnel or organization. Above all, changes must be made by the plant personnel with coöperative advice and assistance from experienced executives and from consultants where needed—not as arbitrary requirements. The problem is not solved by the introduction of "system" but by the modification of production methods to fit the new conditions. Indeed, a basic factor in the current armament production program is the realization by all concerned that the old conditions do not necessarily govern the new although the principles upon which the two sets of factors rest are the same.

The development of standards of normal performances of machines and of men is especially needed. These standards are essential for three purposes: (1) For estimating the time required for manufacturing the contract items and thus accurately predicting delivery dates, uncertainties in which played such havoc in the last war; (2) For planning and scheduling work in the plant to coördinate personnel with work and materials ahead, and (3) For keeping detail tabs on performance of individual operatives to maintain required standards of productivity and develop their initiative, thus insuring expedition of the work and delivery of goods on the dates required for use.

All this may seem like technical detail, and so it is, but the development of management methods in a plant through such detail as this has increased unit productivity in key departments of plant after plant from fifteen to fifty per cent. Moreover, the workmen, through the developments of their initiative and recognition of actual accomplishment, take a lively interest in their daily work. The need for greater productivity and especially the delivery of parts on time can and must be met if we are to produce our armanent quickly.

Mechanization on the March

THE startling success of the German *Panzer* divisions in breaking through the French Army in May 1940 gave fresh impetus to the motorization and mechanization of the armed forces of the United States. Chief among the results of the French collapse was the organization by the U. S. Army of an Armored Field Force consisting initially of an Armored Corps of two divisions, combining for the first time elements of infantry, cavalry, and artillery in one organization under unified command. This highly mobile force of unsurpassed striking power is America's answer to foreign *Blitzkrieg*.



ORGANIZATION OF THE NEW MOBILE ARMY

In action, motorcycle reconnaissance units and fast armored-car scouts will feel out the enemy, probing for traps, mines and ambushes, securing bridges, and establishing strong points. Engineers will span streams and remove road blocks. Next will follow waves of medium and light tanks to crash through the heavier enemy barricades and raid communication lines behind the front. Close after the tanks will roll the motorized infantry to dig in and hold the captured territory. Armored Corps artillerymen will support the advance with 81-mm. mortars, 75-mm. guns and howitzers, and the new 105-mm. howitzer—all equipped for high-speed transport. Air-observation squadrons, also attached to the Corps, will direct the motorized ground units.

By June 1942, the Armored Force will have seven armored divisions, each consisting of 10,000 officers and men, 287 light tanks, 110 medium tanks, 275 heavily armed scout cars, and over 1,000 other vehicles. There are about 500 radios in a division for rapid communication.

An armored division will weigh about 8,500 tons and cost $15,000,000—the equivalent of a light cruiser. However, one armored division has the fire power of approximately six muscle-propelled divisions and can move ten times as fast and march ten times as far in a day. Supplying this speedy force has demanded much ingenuity from the quartermaster units, for it takes 114,000 gallons of gasoline to move an armored division 150 miles, while rolling kitchens must be ready to feed 10,000 men advancing at 20 to 30 miles an hour.

Maj. Gen. Adna R. Chaffee, formerly commander of the 7th Cavalry Brigade (Mechanized), and long an advocate of the mechanized attack, has been placed in command of the First Armored Corps. Headquarters and one division are at Fort Knox, Ky., while the other division is in training at Fort Benning, Ga. Soon other armored divisions will begin to roll into place, and before many months the United States will have its own powerful "blitz force" ready to roar into action at the first threat to our national security. Modern ordnance is the answer to "blitz." (Illustrations on this page and following pages are from U. S. Army Signal Corps photos.)

The Army Rolls

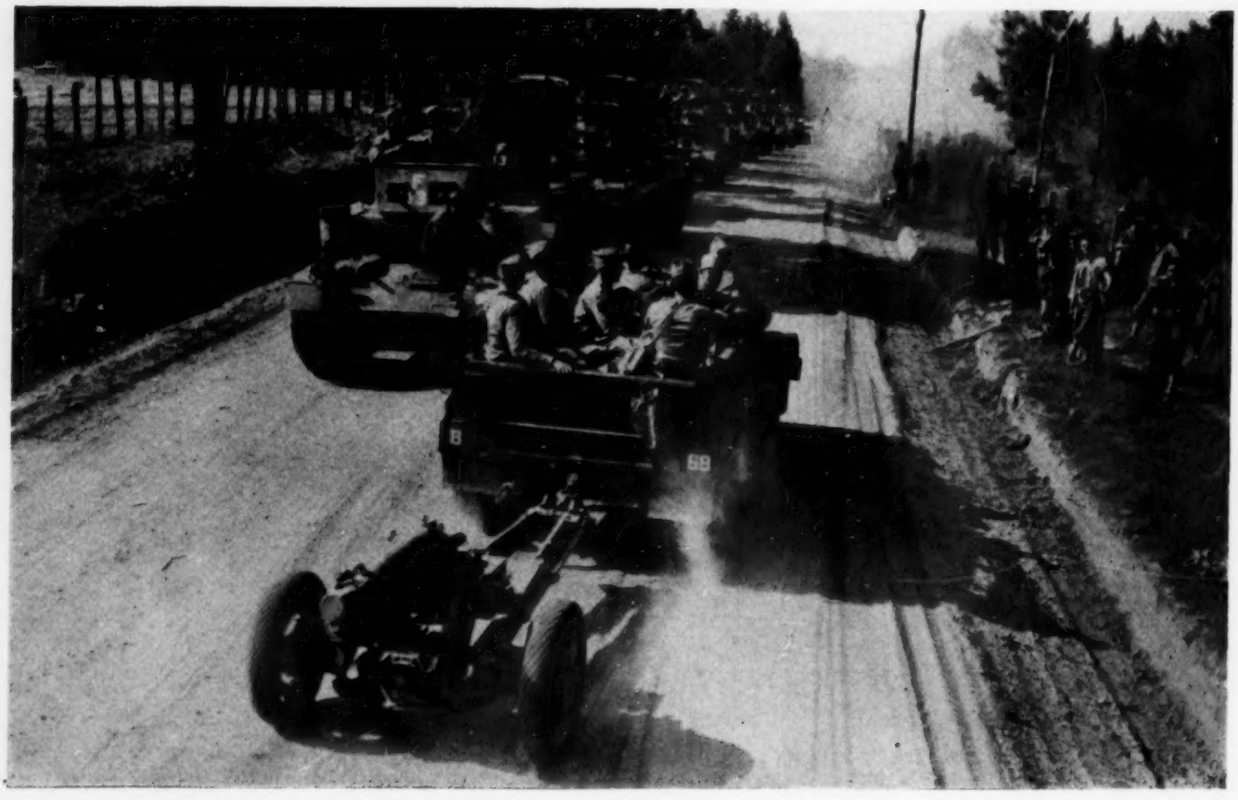
Infantry in the new Army move far and fast in the transport trucks shown above. These motorized units follow close behind the armored forces to consolidate and hold the gains made. Motorcycle scouts, below, precede the advancing forces to reconnoiter, spot mines, traps, and ambushes and report back on enemy troop movements and road conditions.

Mobility for Fire Power

The armored scout cars, above, are some of 275 such reconnaissance vehicles to be included in each division of the new Armored Field Force. They are armed with one cal. .50 and two cal. .30 machine guns. The artillery of the new Army is also highly mobile, as shown below by the 4-ton truck fording a swift stream with a 155-mm. howitzer.

The Tanks Advance

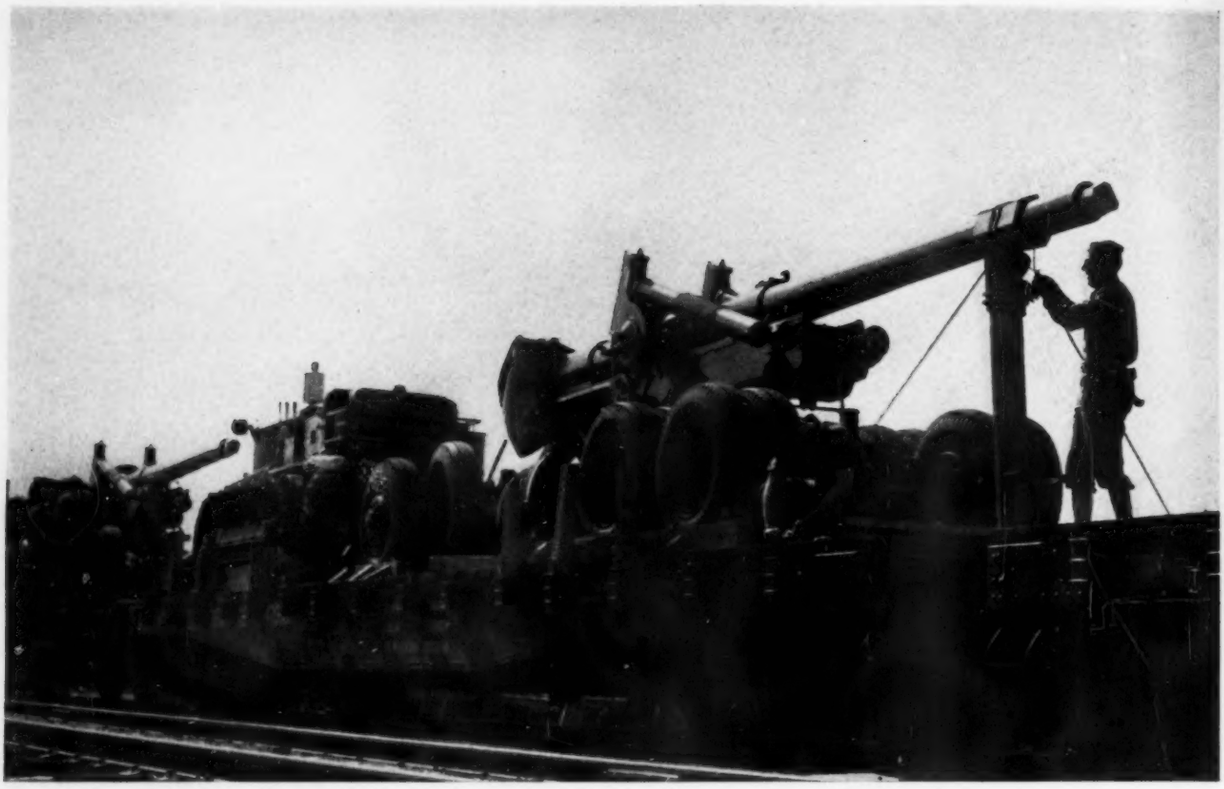
The tank is the backbone of the Armored Force. The medium tank, above, weighs 21 tons and has a speed of 32 miles an hour. It is heavily armored and carries one high-velocity 37-mm. gun and 8 machine guns, two of them adjustable for antiaircraft fire. Below, a half-track truck towing a 75-mm. howitzer passes a group of combat cars during maneuvers.



Treads For Traction

Natural obstacles offer little hindrance to track-laying vehicles. Tanks, tractors, and half-track trucks equipped with flexible treads insure a high degree of mobility for the armed forces of the United States. A combat car, above, plunges through a stream during maneuvers, while below, a tractor pulls a 14½-ton 155-mm. gun (G.P.F.) in sunny Hawaii.

Fast Artillery Transport



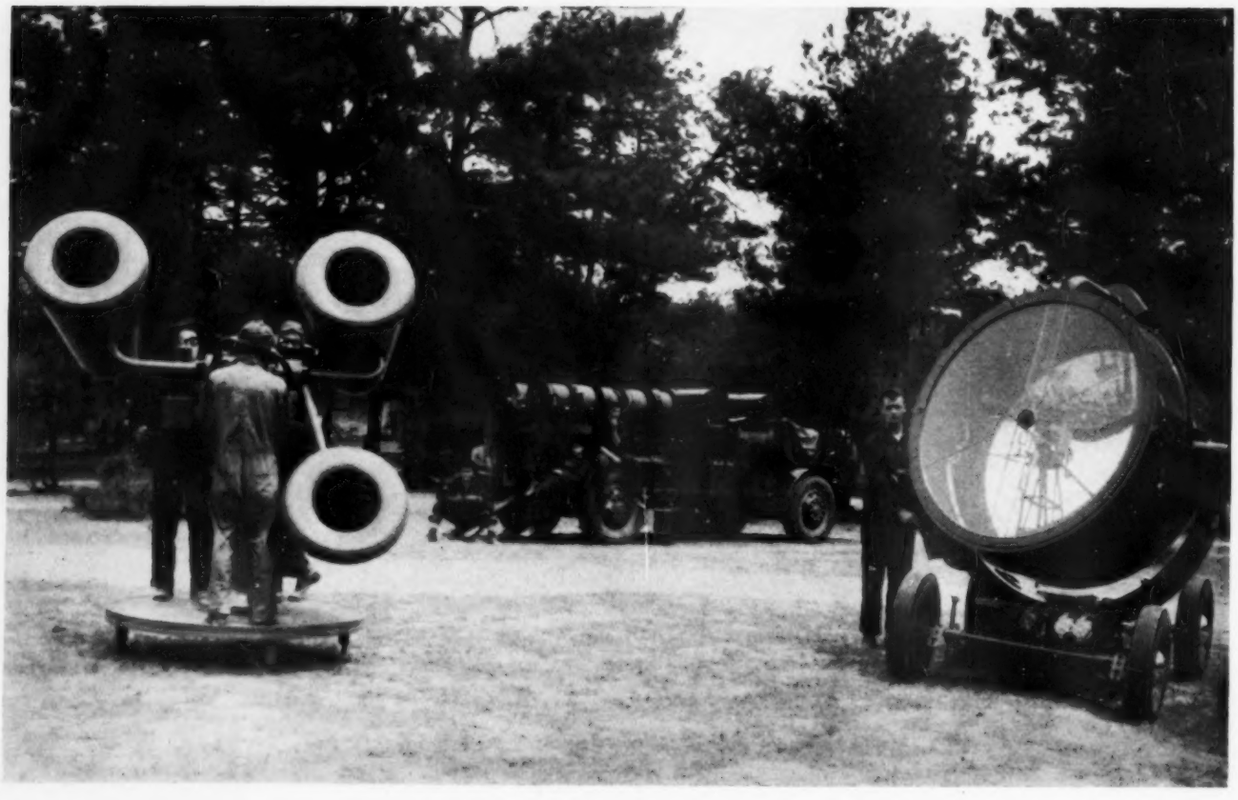
For fast long-distance transport, 155-mm. guns and their prime movers, above, are loaded on railroad flatcars. The 155-mm. gun is the standard heavy field weapon of the Army and has a range of 25,000 yards. Below is the 105-mm. howitzer on mobile carriage. This weapon, which will supplement the 75-mm. gun and howitzer, is a recent ordnance acquisition.

The Guns Go Forward

The 155-mm. gun, shown above with its prime mover, has good cross-country mobility due to its pneumatic-tired carriage and can be towed over roads at high speeds. The half-track truck, with the 75-mm. howitzer on mobile carriage, below, can negotiate almost any terrain and can be brought into firing position rapidly to support a motorized advance.

Mobile Antiaircraft Defense

Antiaircraft defenses of the new Army must also be mobile to follow and protect the motorized troops. Above is a 37-mm. antiaircraft gun on high-speed carriage, while below are three units for night air defense—a sound locator, a 60-inch searchlight, and a power-control truck with generators and cables. The searchlight and locator are transported in trucks.



Mass Production of Combat Tanks

A Case History of Industrial Preparedness at Work

F. A. Stevenson*

LAST May, when the German breakthrough in France was furnishing concrete proof of the importance of the tank as a strategic military weapon, the first tank built by the American Car & Foundry Company for the United States Army was rumbling down the highway to Aberdeen Proving Ground under its own power. There was no fanfare of publicity, but our Army had understood and anticipated the value of fast, highly mobile armored tanks and had placed a contract with the company for a substantial quantity of these units about six months before the German *Panzer* divisions were roaming in and out behind the Allied lines, spreading terror and disorder. It takes a tank to beat a tank, but, unfortunately, the Allies lacked these weapons; hence they were totally unable to cope with the enemy.

The delivery of our first tank to the Army climaxed an immense amount of planning, preparation, and actual production. In early 1939, when the Ordnance Department inquired if the company would be interested in manufacturing tanks, our reaction was that we were well equipped for this type of work. Fundamentally, tanks are heavy vehicles constructed principally of steel. They have certain similarities to the products we had been manufacturing for several decades—steel passenger, freight, tank, and all other kinds of railroad and industrial cars, forgings, castings, and pressings. We had the personnel trained and experienced in the fabrication and construction of such materials and the equipment and facilities required for this class of work. The problems we were accustomed to meet and solve in the manufacture of railroad cars probably would be encountered in the building of tanks.

To check our assumptions, however, we went to the Rock Island Arsenal, which specializes in the building of this type of tank. We were convinced that we would be well equipped to undertake this work if we provided some additional machine-tool equipment. In due course, we informed the Ordnance Department that we would be interested in building tanks. On July 31, 1939, we received the official inquiry.

SINCE it was desired that we should base our estimate upon manufacturing all the tank parts possible in our own shops, a very close estimate was made on each individual part we could make or desired to make. As a result we were able to arrive at the number of machine tools, jigs, fixtures, etc., which would be required to produce the tanks at a predetermined daily rate. We also determined the space required for machining and fabricating the parts and for assembly of the tanks. This necessitated much detail work and required quite a force of estimators, engineers, shop foremen, and executives working literally day and night for seven weeks to complete this estimate. At the end of that time the bid was submitted and every one relaxed for a well-earned rest—a rest, however, that was fated to be short-lived. Our bid was submitted on September 28, 1939, and on October 3, 1939—five days later—we were notified we had been awarded the contract for 329 light tanks.

*Vice-president, American Car & Foundry Company, New York, N. Y. This is an address delivered before the New York Railroad Club, New York, N. Y., January 16, 1941.

We had been the low bidders—astonishingly low, it turned out. Not only that, but our promises of delivery foreshortened anything else offered. The Ordnance Department was obviously enthusiastic but slightly dubious, too. There was a hint of "Now let's see you do it" about their enthusiasm; it will be a fine thing, they seemed to imply, if you can live up to these claims.

Immediately upon receipt of the award, the engineers went back to their drafting boards, the executives back to their desks, the estimators back to their tabulators and the foremen back to their respective places in the shop, and work started all over again. We were faced with the practical problem of living up to the promises which had appealed so much to the Ordnance Department.

The detailed planning of the job was started. This involved making plant layouts; providing the necessary building space, the proper machine tools, and other equipment; the requisitioning, procurement and assembly of materials, and the coördination of all branches of activity for the definite purpose of accomplishing what we had set out to do. The engineers unpacked the blueprints they had prepared to send back to the arsenal, and all these—in excess of 2,600—had to be checked and approved and revisions made where necessary in coöperation with the engineers of Rock Island Arsenal before the requisitioning and ordering of materials could be accomplished.

While we were not the first private company to build tanks or the first shop to build the particular model on which we had bid, we were, however, the first company to offer to build this quantity of tanks in the time specified by our bid. Rock Island Arsenal had been building tanks for some time and proved exceedingly coöperative in helping us solve the innumerable difficulties that were destined to confront us.

IMMEDIATELY after receipt of the award we discovered that our greatest difficulty lay in the procurement of armor plate for the tanks. When we prepared our estimate, we expected to purchase all the armor plate already fabricated. After the award was made, it was found that the purchase of armor plate from the two established manufacturers was not possible within a delivery time that would permit us to meet our tank delivery schedule. One of these suppliers was willing to furnish the thinner sizes to meet our schedule. We were, however, unable to purchase the heavier thicknesses in time to meet our requirements. The quotation we received on this plate to meet what was called an accelerated schedule was not only considerably in excess of the price we expected to pay when the estimate was prepared but so high that we began to consider seriously processing the armor plate ourselves.

After considerable study we concluded, since a great portion of the total weight of the tank armor is made up of the heavy plate, that the only answer to the problem lay in setting up the necessary facilities to manufacture this plate ourselves. We had anticipated that such a condition might occur and had fortified ourselves with an investigation into the materials

and equipment we would be forced to provide in the event armor plate could not be purchased.

We realized we were confronted with a huge task of manufacturing tanks to meet a definite delivery schedule, which required building up our output to three tanks each working day. Secondly, we were faced with the problem of going into another major line of business; that is, the processing of case-carburized armor plate. In addition, we had to find out how to manufacture a product which heretofore had been shrouded in mystery.

We therefore came to the conclusion that separate and distinct departments must be set up for the handling of this business with entirely separate organizations. Consequently, there was established in our Berwick plant an ordnance division with two separate and distinct departments and organizations—one for the manufacture of the tanks and the other for the processing of armor plate.

IT probably is unnecessary to mention the difficulties encountered in acquiring the machinery needed, for already the machine-tool industry was beginning to feel the pressure that was to become so heavy just a little later. In less than four months we provided, installed, and completely tooled up seventy-five machine tools and built and completely equipped a new plant for the processing of armor plate. While the buildings were being prepared and the machinery installed, the purchasing department was securing prices for materials to be purchased complete and for those parts which we were to make. A method usually was followed whereby any reputable manufacturer who could furnish the parts and was willing to do so at a fair price was given the job. We found it expedient to purchase the necessary jigs and fixtures from toolmakers in various large cities, for in the time allowed to prepare these special fixtures we did not have available the tool-room machinery upon which they could be manufactured. At this very time, the fall and winter of 1939 and 1940, the Berwick plant tool-machine shop was working twenty-four hours a day getting out dies and tools for the various car orders on the books.

The planning of this job, including the requisitioning and purchasing of materials, providing the necessary shop space, the procurement and installation of machine tools and other equipment, and providing the necessary tools, jigs and fixtures, was so handled that by January 1940 we were able to assemble a pilot tank with soft steel plate instead of armor plate to prove out our jigs. The first tank with armor plate was started March 22, 1940, and accepted April 30, 1940.

It might be in order to mention at this point that our original contract was dated October 23, 1939, with commitment to start delivery 200 days from that date. As it turned out, although we received an extension of time on account of certain changes made in the design of the tank, this extension was unnecessary, for our first tank was accepted in 184 days; that is, 16 days prior to the promise we made in our bid. Our original contract completion date was January 11, 1941, while the entire order was completed in December 1940.

With the commencement of production, new troubles arose on all sides—the majority of them minor but none the less irritating. For example, as the company in times past had driven a billion rivets, more or less, we had expected no difficulty in that phase of tank building, but driving the 2,000 rivets in each tank proved to be one of the toughest parts of the job. These rivets were made from air-hardened steel and were difficult to drive, especially with a pneumatic hammer.

The standard of workmanship required on tanks is high. It is one thing to build a steel car destined to run its life on smooth, carefully constructed tracks; it is, we discovered, an entirely different thing to build a vehicle whose ultimate employment is the roughest usage possible; which is expected to traverse rutted fields and tangled woods where no roads are possible; to splash across unbridged streams; to be subjected at times to having its full weight thrown upon itself—some twelve tons of steel hitting the solid earth at a velocity of upward of forty miles an hour—and yet to come through this punishment solid and steady, figuratively asking for more. Therefore, this vehicle had to be built with the greatest precision to meet the required tolerances. We found, for instance, that drilled holes really meant reamed holes.

The minimum weight to accomplish the purpose intended is an essential feature in tank design. Light weight increases the speed obtainable from the horsepower of the engine employed and gives additional mobility in difficult terrain. For this reason all parts are designed for light weight, and, on account of the service, high-alloy steels are used which are heat-treated to develop their full strength. The final effect of this on production is that in almost all cases we have hard, tough steels to machine, and this requires good machine tools.

In the machining of the tank parts we used practically all varieties of tools: vertical and horizontal milling machines; thread-milling machines; cylindrical, surface and internal grinding machines; turret lathes; broaches; horizontal and vertical boring mills; thread grinders; vertical turret lathes; radial drills; planers, and shapers. We also used two automatic profiling die-sinking machines as production tools.

Contrary to the usual design for a wheeled automotive vehicle, the tank has no chassis; the armor plate not only furnishes protection from enemy fire but is, in addition, the structural frame. This requires close tolerances as well as flat armor plate. No shims are allowed in fitting up the engine supports, nor other mechanisms attached to the armor plate.

THE tanks are assembled by the progressive system similar to that used in building railroad cars; that is, after several bench positions, the wheels are applied and from then on to the assembly of the caterpillar track the "hulls" roll on their own bogie wheels. Alignment on the final assembly track is maintained by allowing the wheels to run in a grooved track on the floor of the shop. Between the start of the hull and the acceptance test there are forty-three tanks. This does not mean that there are forty-three assembly positions, as there are several steps which require more time to accomplish than is allowed for one position. For example, the riveting of the main structure requires 8 hours, and building 3 tanks a day allows only 2 2/3 hours. Consequently, to build 3 a day, 3 positions in parallel are required. Actually there are 26 working positions in the main assembly line.

The assembly line is in two parts: all fitting and driving of rivets in the hull and turret are done on one assembly line, and when the hull is complete it is transferred from the hull assembly to the final assembly line. The suspensions and wheels, insulation, prime coat and second coat of paint are applied before the tank is transferred to the final assembly line. When it arrives at this line it is simply a box-shaped structure which is called the hull.

As the tank moves down the channel track, successive applications are made of the operating levers, transmissions, oil and gas tanks, electric wiring, piping, instruments, etc.

The turret is applied after being carefully machined for easy rotation. Finally, the engine is mounted and the caterpillar track applied. From then on, the tank moves by its own power. Of course, all the units applied to the tank are subassembled at locations convenient to their application.

Every single piece which we furnish is applied to the tank before road testing. This test of seventy-five miles is made by the Ordnance inspectors who have had long experience in this work. They can detect unusual noises even above the rather disconcerting rumble inside the tank. Periodically during the test they examine all working parts for faulty application.

After test, the tank is immediately inspected and if acceptable is washed and painted. Final acceptance is made after painting. After this, the tank is driven by its own power into an end-door automobile car and blocked for shipment. I might state here that, to my knowledge, no claim for damage to a completed tank has been made against a carrier.

ON this first order for 329 tanks the company built up to a daily production of 3 tanks. We recently have received orders for additional light tanks on which production has begun. These tanks incorporate certain design changes resulting from observance of actual combat conditions abroad at the present time. We anticipate beginning shipments in March and producing at that time at the rate of four tanks a day, building up to a maximum output of fifteen tanks a day.

In addition to the above, we also manufacture in our tank-building departments the tank suspensions, or what might be called the running gear, for tanks being built in Canada and England for the British Government. We have been awarded a large quantity of tank sets, of which approximately 400 have been completed and shipped. These are being produced at the rate of five sets a day, which production will shortly be increased to six sets a day. This may sound like a minor job, but with a few additions of machine tools to those being used for this particular contract we would be able to produce in our machine shop at least four additional American light tanks each working day. Involved in each set are 208 pieces requiring 798 machine operations. Some of the operations are the most difficult we have been called upon to perform, requiring, of course, most accurate workmanship.

Also in our armor-plate department, in addition to producing armor plate for the tanks at a production rate up to fifteen tanks a day, we have taken on armor plate for a large number of half-track scout cars being built by other contractors. This business, together with additional tank business, of course, has necessitated the acquisition of numerous additional machine tools, furnace equipment, etc., as well as providing additional floor space for processing this plate.

The following figures will show the magnitude of the operations required to produce tanks and armor plate:

1. In the tank-building department, for a production of 3 tanks a day, which was the maximum on the first order of 329 tanks, we required 42,500 square feet of floor space for our tank machine and assembly departments. This, of course, was in addition to such fabricating as was done in existing departments of the car plant. For the increased production on the additional business, where we will build up to an output of 15 tanks per working day, the floor space required for the tank machine shop and assembly departments becomes approximately 175,000 square feet.

2. For the armor-plate department, our original installation required 27,500 square feet as compared with 200,000 square feet of floor space required to produce the 1,000 tons per month necessary to meet the delivery schedules of armor-plate business on order.

3. In the manufacture of parts for the tank at the rate of 3 tank sets a day, we required a total of 45 machine tools, in addition to those used in existing departments of the car plant; whereas for a production of 15 tank sets a day we have provided a grand total of 300 machine tools.

4. In the armor-plate department, to produce armor plate of the heavier thicknesses for 3 tank sets a day, we secured 30 machine tools as compared with a grand total of 202 for the production of 1,000 tons of armor a month.

5. Two carburizing furnaces originally were installed, and we now have installed, for the higher rate of production, a total of sixteen of these furnaces, of much larger size than the two originally purchased.

6. We originally provided one annealing furnace and now have nine.

7. For heat treating, we originally had five furnaces and we now have twenty-one—all fully equipped with thermostatic controls, quenching tanks, automatic regulators, etc.

8. In the tank machine shop, 60 Warner & Swasey turret lathes, 43 milling machines, 21 radial drills and various other tools in lesser numbers are used. The armor-plate department now has installed 43 planers and 51 radial drills.

9. A total of 2,663 drawings is involved in the manufacture of these tanks. A total of 2,865 different kinds of parts or a grand total of 14,318 individual pieces are required for each tank, exclusive of the engines and accessories. The machining of the parts for each tank involves machine work upon some 705 individual items upon which 2,728 operations are performed.

10. The principal assemblies in the tank are the transmission, hull, turret, suspensions, caterpillar track, clutch, and gun mounts, as well as various control assemblies and other miscellaneous units. Each of these involves very accurate workmanship and numerous parts—253 different parts in the transmission or a total of 1,087 pieces; 221 different parts in the hull or a total of 930 pieces, etc.

It might be interesting to note that ninety-five per cent of the operations involved in the manufacture of the parts, the assembly of the tank, and the manufacture of the armor plate were handled on a piece-work basis.

THE question may present itself as to where the company obtained the necessary workmen to man all the various machines and perform the precision operations on the first order of tanks, and how we are going to meet the problems of manning the various machines for the greater output required. The answer to this is that we have instituted a method of training employees to perform certain definite operations on certain parts and on certain machines. These machines are tooled in such a way that with proper supervision the minimum of inaccuracies result. Our method in training is to employ so-called "learners" who work with experienced operators. As a result, in a period of six to eight weeks, if they approach the task in the right attitude, they become familiar enough with the operation to operate their own machines in a satisfactory manner. These men are not machinists but merely operate certain machine tools to produce certain definite parts. This is the factual story of American Car & Foundry Company's production of light tanks and armor plate in the present emergency.

THE NEW ARMS PLANTS

The Four Plans Recommended by the War Department for Procuring New Facilities

	Plan I.—Government Ownership	Plan II.—Private Ownership with Government Interest	Plan III.—Privately Owned	Plan IV.—Ownership in Defense Plant Corporation, R.F.C. Subsidiary
Purpose	For plant in which Government desires to have permanent interest or in which the manufacturer has no future interest.	For plant in which the manufacturer desires to preserve a future interest.	When manufacturer desires to own the facilities at all times and does not include in the product price an abnormal amount for depreciation or amortization.	For plants which it is not desired to finance under Plan II and in which the manufacturer desires to preserve a future interest.
Financing	Government funds, Army or Navy.	Private, including R.F.C. loan.	Private.	With funds of Defense Plant Corporation.
Title	Vested in the Government.	Vested in the manufacturer.	Vested in the manufacturer.	Vested in Defense Plant Corporation.
Method of Operation	Leased to the manufacturer.	By manufacturer.	By the manufacturer in the normal way.	Leased to the manufacturer.
Reimbursement	None.	Cost to be repaid to manufacturer in 60 equal monthly installments. Payments to be subject to acceleration if supply contracts run out.	None, other than by normal depreciation.	None.
Amortization	No amortization involved.	Certified for tax purposes by Certificate of Necessity in interest of national defense and Certificate of Government Protection; also Certificates of Nonreimbursement under supply contracts.	Certified for 5-year amortization by Certificate of Necessity in interest of national defense and Certificate of Nonreimbursement under supply contracts.	No amortization involved.
Termination	Government retains ownership of facilities at termination of lease.	Government pays balance of costs, takes title and assumes construction obligations if facilities not completed.	None.	Defense Plant Corporation retains ownership of facilities at termination of lease or transfers same to Government through War (or Navy) Department.
Subsequent Use by Manufacturer	No provision, except in special cases.	Upon termination or at end of 5-year period, plant may be permanently acquired from the Government by paying original cost less agreed depreciation or lower negotiated price.	No provision required.	Upon termination of lease (and/or in some cases during term of lease) plant may be permanently acquired by manufacturer from the Defense Plant Corporation by paying original cost less agreed depreciation or lower negotiated price (or on some other basis agreed upon in certain cases).

Statistical Methods and Quality

Their Contribution to Development and Use of Specifications

Capt. Leslie E. Simon*

ALL have heard of the blind man in a pitch-dark room trying to find a black cat that was not there. I believe that a man would be in much the same position if he tried to write a specification without statistics. I say this, knowing full well that quite workable specifications are written by men who have no knowledge whatever of formal statistics. However, these men are nonetheless users of statistics. Without attempting to credit all successful achievement to statistics, it is evident that by keen native judgment and observation, these men have indirectly attained satisfactory specifications. But the problem of dealing with a variable product is fundamentally statistical, and these men could have achieved their desired end much more economically, swiftly, and unerringly with the proper statistical tools.

The distinction between the use and nonuse of statistics in this situation, is perhaps similar to that between the two hunters, one of whom is armed with a spear, the other with a rifle: Both may succeed in eating, but one must strive for a precarious existence, while the other may live in relative comfort. So in writing good specifications: they may be reached eventually by the brute-force method of trial and error and hard common sense, but can be attained with greater ease and certainty through the use of the scientific aids offered by statistical theory. It is of the contribution made by this powerful auxiliary that I wish to speak.

Several years ago I was given what I believe to be an unusual opportunity to observe the functioning of purchasing specifications, their relationship to standards of quality, and the power of the statistical technique in ascertaining and defining quality with swiftness, clarity, and validity. Since this experience is of a military character I shall, for obvious reasons, confine myself to broad scientific principles which are of general application both to Ordnance problems and to many problems in industry. I may, however, define the experience by stating the general circumstances.

IT is necessary for the Army to maintain stocks of ammunition. Unfortunately, ammunition is subject to deterioration in storage. It therefore follows that after a period of years, investigations must be conducted to determine the nature and extent of the deterioration, and lots of ammunition must be assigned to various grades, with a view to their ultimate replacement when their quality becomes too poor.

In order to detect deterioration, one must know what the quality was originally. It is but natural, therefore, to look to the procurement specification as at least an indication of the desired initial quality. Since there is frequently some doubt about the meaning or efficiency of the procurement specification, one supplements this knowledge by a critical examination of all the acceptance tests, subsequent tests, and recorded service use which pertain to the ammunition. This procedure gives a keen insight into both the level of quality which was current at the time, and the efficiency of the procurement specification as an instrument for obtaining a product of the apparently intended level of quality.

Finally, tests must be performed to determine (at least within limits) the existing level of quality after deterioration, if any, has taken place. Since the function testing of ammunition is both destructive and costly, it is highly desirable that all possible information be extracted from such expensive test data. Statistical methods are therefore used in the analysis of test data. They provide reliable protection against the frailty of human judgment in estimating the quality of lots of ammunition from the results of tests of samples taken from those lots and are a cogent factor in making judgments comparable when made from time to time and by person to person.

This procedure throws much light on the operation of the statistical method and the results which might have been obtained had these methods been in use at the time the ammunition was originally accepted. At least some of these principles have now been applied to current procurement specifications. I would like to take this opportunity to express my gratitude to Dr. Walter A. Shewhart for his generous help and patient advice while I was devising the system of surveillance of ammunition which has now been in use for over two years.

SOME of the contributions of statistics to the development of specifications and standards of quality can best be shown by first analyzing the conditions which exist in the absence of the statistical method. The attainment of one's professional end under these circumstances is sometimes highly imperfect, slow, and costly. When it becomes necessary to procure a product in quantity, there is generally a considerable degree of incertitude both as to the level of quality which is necessary and sufficient for the purpose intended and as to the level which is practically attainable in manufacture. These levels, if clearly defined, would surely form the basis of a sound and economical standard of quality.

It appears that the management frequently avoids the tedious problem of determining an economic standard of quality, of evaluating the statistical constants associated therewith, and of devising an inspection procedure to insure to an appropriate degree the meeting of the standard by what appears to be a clever and practical stratagem. They merely decide not to bother about either the standard or the statistics (perhaps on the grounds that it is impractical or at least troublesome) and instead write a good, stiff acceptance specification with a view to getting the very best obtainable. I think that sly old Æsop could have written a good fable about this attitude. It carries grave penalties.

Of course, an acceptance specification calls for inspection. Inspection is always costly, and therefore some sampling scheme is generally adopted in the interest of economy. In the case of ammunition, sampling must suffice, since a function-

*Executive officer, the Ballistic Research Laboratory, Aberdeen Proving Ground, Md. Captain, Ordnance Department, U. S. Army.

This article was presented recently as an address before the Symposium on Statistical Methods in Engineering at the University of Pennsylvania Bicentennial Conference. It expresses the personal views of the author and does not represent official policy on the subject.

ing test of the entire product results in its total destruction. The specification therefore generally reduces to one or more requirements of the form, "a test (sample) of n shall be selected at random from each lot, batch, or consignment of the product, and not more than c shall fail." The n used in most of these specifications is very small. I wish to show that this popular and well-known type of specification offers almost no guarantee of the quality of product which will be accepted thereunder and that the quality of product accepted under such conditions is practically that which happens to be offered for inspection.

SUPPOSE, for example, that a manufacturer submits a lot for acceptance of which the fraction p are good and the fraction q are failures, or more specifically, q is the fraction defective. It is easy to show by the binomial distribution that such a lot has a definite probability, P_b, of passing the above specification where,

$$P_b = \sum_{k=o}^{c} \frac{n!}{(n-k)!\,k!}\, p^{n-k} q^k .$$

It is thus evident that if manufacturer A makes a very good but not quite perfect product, some of his lots will be rejected; and if manufacturer B presents only very bad lots, some of his lots will be accepted. In general, if a large number of lots, all having the fraction defective, q, are presented for acceptance, then 100 P_b per cent of the lots will be accepted and 100 $(1-P_b)$ per cent of the lots will be rejected.

The most discouraging factor, however, inheres not in the rejection of some good lots or in the acceptance of some bad lots but in the fact that the accepted lots in this case are no better than the rejected lots. Suppose that k manufacturers produce lots each of fraction effective $p_1, p_2, \ldots p_k$, respectively, where p_1 to p_k represents a limited range which in practice may be of the order of 0.99 to 0.85. Each manufacturer will have his lots rejected with more or less frequency, but the accepted lots of a manufacturer will be no better than the rejected lots.

Whereas no precise statement can be made as to the average quality level of product accepted from a group of manufacturers without a knowledge of the number of lots presented at each quality level, it nevertheless is obvious that the average of the accepted quality will differ little from the average of the presented quality, and that the limits are the same, even though one require that there shall be no defectives in a small sample of n. For the case of zero defectives in a sample of ten, and equal frequency of all kinds of lots from 0.99 to 0.85, the average quality levels are 0.92 (presented) and 0.94 (accepted). For a specification of not more than one defective in ten, they become 0.92 and 0.93.

It is therefore clearly evident that the quality of product accepted under the old type of specification is practically that which happens to be offered for inspection. It also appears that the only way to prevent the acceptance of poor quality consists in not allowing it to be presented for inspection. More will be said of this subsequently.

This unhappy situation cannot be corrected by any simple remedy, for the same law applies whatever the value of c. Suppose that one reduces c to zero in an effort to improve quality. What is the result? A plot of the binomials, which in surveillance is called the operating characteristic of the specification, readily shows that the frequency of rejections of lots of poor quality is somewhat increased; so is the frequency of rejections of lots just short of perfection. The penalties fall on both the just and the unjust as one is merely subjected more mercilessly to the rigors of an unjust chance, and the other merely permitted to profit less from its vagaries. The unsatisfactory condition remains unaltered, and additional grounds for producer dissatisfaction may have been introduced. Quality becomes a function of margin of profit: the larger the margin of profit, the greater the number of rejections the manufacturer can afford; and, consequently, if it costs more to produce good quality than poor quality, the more he can consciously lower his level of quality in the interest of making maximum profit.

On the other hand, one does not get what he does not pay for, and too small a margin of profit may well be a deterrent to good quality. It is conditions like these that must have inspired the doggerel:

"The rain falls alike
On the just and unjust fellow,
But mostly on the just because
The unjust has the just's umbrella."

These observations become clear in the hindsight of inspecting the record of what actually occurred. They might well have been clear beforehand had one applied no more complicated statistics than that of the binomial distribution.

THE analysis thus far, however, is wholly destructive. It neither points out the basic faults nor suggests their remedies. A little further use of engineering sense and statistical methods will accomplish these constructive ends.

In the critical examination of long records, such as those encountered in large contracts, one can make some important observations. One can clearly see, for example, that manufacturer A made a very good product, yet a moderate number of his good lots were rejected because of choice of acceptance criteria. On the other hand, the whole record shows that manufacturer B made a perfectly abominable product. He suffered a greater frequency of rejections than Mr. A, but he certainly managed to get many of his poor lots accepted before he went bankrupt or was barred from business—or perhaps he survived despite his lack of merit. All of A's lots should have been accepted; none of B's. *One basic fault then lies in judging each lot on its own merits on a small sample basis which even in the case of homogeneous lots is obviously not an efficient basis for discrimination between good and bad lots.*

If then, a large sample is economically prohibitive, one must turn to some other source of information. This information is, in general, abundantly available. It exists in the past performance of the manufacturer. It is a part and parcel of a very valuable asset which is generally called experience and expert engineering judgment. When data are costly and scant, no scrap of pertinent information should be allowed to escape; and statistics supplies a competent means of determining the validity of the prior knowledge and of mathematically combining the accumulated knowledge with that supplied by the sample itself.

Another fault is failure to make use of available knowledge other than that supplied by the sample, but the cogency of this criticism may not be apparent without a brief description of the mode by which the statistical method makes efficient use of this knowledge.

The technique of checking the validity of accumulated prior knowledge and of combining it with that supplied by the sample is a very common-sense rather than a technical procedure. It requires for its operation only three ideas: (1) the concept of statistical uniformity, (2) the operation of an elementary statistical technique, and (3) recognition of a simple empirical law.

IRRESPECTIVE of homogeneity, one has almost certain (not just probable) knowledge of the product actually sampled. However, any inference drawn about the remainder of the lot inheres in some relationship, known or unknown, between sample and lot. Unless a product be homogeneous in the sense of being statistically uniform, inferences regarding the lot, based on the observation of samples taken from that lot, must be severely circumscribed, since the reliability of sample quality as a witness of lot quality is unknown.

On the other hand if statistical uniformity exists, and one knows the general level of a quality characteristic, and the measure of its variation, then statistical theory can predict the limits within which practically all samples of any size, *n*, should lie. One can obtain the knowledge of the general level of a quality characteristic and the measure of its variation from the accumulation of a large number of small samples. One then can predict the statistical limits of sampling fluctuation for practically all samples of size *n*. If a sample fall outside these limits, it appears that a state of statistical uniformity does not exist. If, however, no samples fall outside the limits, there is at least no reason for not believing the product to be statistically uniform. This inference is dependent upon an empirical law.

Extensive experience has shown that once a state of statistical uniformity is attained in a manufacturing process, the state of quality is inherent in the process itself, and cannot be changed without changing the process.

With these three ideas; *viz.*, statistical uniformity, a statistical technique, and an empirical law, and with these three pieces of knowledge; *viz.*, a state of statistical uniformity, the quality level, and the measure of sampling fluctuations, the small sample becomes a significant index of lot quality. The steps to significance are two. First, the state of statistical uniformity, level of quality, and measure of variation are inferred from the accumulation of samples. (This is the abundantly available information.) If statistical uniformity cannot be inferred from the data, then efficient discrimination between lots of good and bad quality by means of small samples is impossible. Secondly, if the quality be satisfactory and if a subsequent sample fall within limits, there is no reason for believing that the satisfactory quality level has changed; but if it be not within limits, then the quality level appears to have changed from the known satisfactory level. (This inference comes from the information of the sample.)

These are essentially the principles used in Dr. Shewhart's Criterion I for quality control in manufacture. *Concisely, then, one may say that whereas one cannot judge, except most approximately, the quality of the lot from the small sample, one can judge by statistical methods whether or not there is any reason for believing that the lot is of a different quality level from its predecessors; and knowing the quality level of the predecessors from accumulated data, one then can infer the quality of the lot with considerable assurance.* Hence, the second and corollary fault in the specification consists of not using hindsight as a guide to foresight.

In the light of these observations, let us consider the rôle of statistics in the development of a purchasing specification. One is in an ill position to write a specification unless one knows what one wants in the first place. Even if one knows what one wants, it does little good to specify it, unless there is at least some assurance that it can be met. Hence, that which is ideally desirable must be tempered by that which is practicably obtainable. The only way to ascertain what is practicably obtainable is through examination of records.[1]

FROM a long run of records one readily can determine the fraction defective, the average, the standard deviation, or other measures of the principal quality characteristics of the product which should be expected under good manufacturing practice. In my own case, I generally consider every recorded test of the product under consideration and often the tests of allied products. Without statistical methods, a fair consideration of such mass data would be almost impossible. The statistical method, furthermore, is essential as a means of inquiry into the homogeneity of the product, for without a state of statistical uniformity (as has just been pointed out), one is very limited in drawing conclusions regarding the lot based on the observation of samples.[2] If a homogeneous product of satisfactory quality level can be produced economically under good manufacturing practice, then one is in position to describe an economic standard of quality. Whereas the standard may or may not be the specification quality, it is nevertheless a desirable fundamental for writing the purchasing specification.

It is impossible to specify completely a definite series of operations which will detect with certainty that a very simple product is or is not of standard quality. Some of the quality characteristics are not capable of definite measurement, and, after all, there is a limit to detail. Hence, the specification of the intended quality must be limited to some chosen or principal quality characteristics of the product. This is termed the design specification, as it describes the design which it is intended that the specification shall obtain.

Statistics makes an important contribution to the design specification as the intended or aimed-at values of the quality characteristics of the design and their tolerance limits can be described most concisely by such statistical measures as the average and standard deviation. In surveillance work a quality description or design specification is prepared for each grade of ammunition of a given kind. Furthermore, it should be noted that a sound foundation for the statistics of the quality characteristics described in the design is provided by the investigation of the record which was made in the interest of the standard of quality.

THE contribution of statistics to the acceptance specification is perhaps more marked. In the acceptance inspection, which is generally on a percentage basis, it is obviously impossible to determine with certainty that all of the product will meet the ideal of the design. Here again it is necessary to compromise with practicality and frankly admit that the logical mission of this specification is a mere statement of *the quantity and kind of evidence which will be accepted as a satis-*

[1] When the product is new, resort must be made to the process described under "The Judgment of Statistical Control," Chap. I, pp. 43-46, and Chap. II, pp. 50-79, Statistical Method, by W. A. Shewhart, the Graduate School, Department of Agriculture, Washington, D. C., 1939.

[2] Chap. X, pp. 121-144 *et seq.*, "Economic Control of Quality of Manufactured Product," by W. A. Shewhart; D. Van Nostrand Co., New York, 1931.

factory indication that the product will meet the standard of quality. It describes no indefinite ideals but confines itself to the delineation of a sequence of operations to be performed upon the product, the interpretation of the results of such operations, and a definition of the limits within which such interpreted results must lie in order for the product to be acceptable. In surveillance, this procedure is, of course, the criterion by which lots are admitted to the respective grades described by the design specifications for those grades.

The objectivity of the statistical method makes it ideally adapted to the rôle of drastically limiting the need for interpretations of requirements. The necessity of interpretations and vague estimates usually opens the field for differences of opinion, whereas the statistical method swiftly produces the estimate of the measure under consideration in a manner superior to unaided judgment and without the bias always associated with personal consideration. This is a great step toward placing both purchaser and vendor on solid ground of mutual trust and understanding. Furthermore, in the light of the statistical technique the probability of accepting poorer than standard quality can be consciously minimized to any degree which appears to be economically desirable. One can do much to reduce the chance rejection of good lots and the chance acceptance of bad lots.

Without an exhaustive investigation into the reasons for each step, which would be somewhat tedious, let us see one way (a number of others could be suggested) that a few modifications in principle can be made in the popular type of specification in order for it to have these manifold advantages.

a. From the first lot of a series k, test samples of n shall be taken as nearly as practicable in order of manufacture and the fraction defective, q, of each sample computed. The average of all q's shall not exceed the specification value, q', and no q shall depart from the average by more than three times the standard deviation of q.

b. From subsequent lots of a series, a test sample of n shall be taken at random and the fraction defective, q, computed. The observed q shall not depart from the average of all q's by more than three times the standard deviation of q (based on all accumulated samples) nor shall it cause the average of all q's to exceed the specification value, q .

c. In event of a rejection, the next lot presented shall be considered a first lot of a (new) series.

Detailed steps in the specifications and provisions for retests have been omitted in the interest of focusing attention on statistical measures.

Part *a*, which involves a relatively large sample, has two objectives: First, to subdivide the lot into subgroups with respect to time in order that undue variation in the lot from part to part can be detected; secondly, to provide a large sample from which quality can be estimated with a high degree of precision, thereby providing effective discrimination between the manufacturer who has an established process in which the inherent quality level is good—*i.e.*, of specification quality or better—and the manufacturer who is poor and who would ride as a parasite on the sampling fluctuations provided by a kindly chance. Part *a* makes relatively efficient discrimination on a small sample basis subsequently possible. It may be noted that the difference produced by the relatively large sample of kn is only one of degree, but it is nevertheless an important difference.

Part *b* is a step designed merely to detect a change in quality. It should be noted that it is necessary to take adverse action if there appears to be significant change in quality, even though the sample which is indicative of the change might be acceptable if the average quality level inherent in that manufacturer's process had happened to be lower but still within specifications. This situation must obtain since such an instance indicates either a change in average quality level or a loss of statistical uniformity and hence results in an unknown situation, and one can no longer validly use the accumulated inspection data in predicting from sample to lot.

Part *c* is, of course, an avenue (though a somewhat painful one) for the manufacturer to reëstablish himself.

These measures provide for an adjustment in acceptance criteria whereby the probability of rejection of a product of specification quality can be made very remote without prohibitive sampling. However, in attaining this end, the door has not been opened to the acceptance of poor quality for (1) the manufacturer has to qualify first on a large sample basis, and (2) if he should relax his quality after qualification, he might succeed in passing one or two poor lots, but the probability of several poor lots becomes increasingly remote, and once caught, he has to start all over again with a new first lot of a series. The operation of these principles on accepted stocks not only shows their advantages in bold relief but also shows the great gain that would be made if the influx of poor quality were checked at the time of its occurrence.

STATISTICAL methods have been invaluable in evolving standards of quality for ammunition, for specifying grades based on these standards, and for writing the specifications for admission of lots to these grades. In the field of procurement specifications their use has not been as extensive, because the need has not been felt so keenly. Nevertheless, some progress has been made. Statistical methods have proved to be a powerful tool in the critical examination of some ammunition specifications prior to final approval. Their use, either directly or indirectly, is almost essential in determining a reasonable and economic standard of quality through the method of comparing the quality desired with that which can be reasonably expected under good manufacturing practice. In like manner the statistical technique renders a valuable service in framing the acceptance specification. Through its use, the quantity and kind of evidence which will be accepted as proof that the product will meet the standard of quality can be clearly expressed in a fair, unequivocal, and operationally verifiable way.

EDITOR'S NOTE: The statistical methods described by Captain Simon in the above paper have been the subject of much discussion in engineering and industrial circles during recent months. Their application is not alone in the field of ammunition but relate as well to the specifications and control of any perishable commodities which are stored over long periods of time and in large quantities. Captain Simon presented another paper before the American Statistical Association and the Institution of Mathematical Statistics at their meeting in Chicago, Ill., during December 1940. This paper dealt with "the initiation of statistical methods of quality control in industry." Methods based on these premises have done much to increase quality both in manufacture and in storage and to predict storage conditions as no other method of similar speed and simplicity has been able to do thus far.

Rearmament Progress

Statistics of the Current Program

The following list of production contracts with private industry is published as further indication of the steady progress being made by the Ordnance Department of the Army in the production of military armament. Orders placed with Government arsenals and those below $25,000 are not included. These orders were placed during the period December 1, 1940 to January 31, 1941. For earlier orders under the military rearmament program, the reader is referred to the three preceding issues of this journal. Major national-defense contract categories include: $3,300,000,000 for ships; $1,500,000,000 for construction of factory expansion and for housing; $1,500,000,000 for airplanes and parts; $600,000,000 for ammunition; $500,000,000 for guns; $400,000,000 for trucks and tanks. These contracts, plus such British and other foreign material orders as have been placed at the present time, call for: 50,000 airplanes; 130,000 engines; 17,000 heavy guns; 25,000 light guns; 13,000 trench mortars; 33,000,000 loaded shells; 9,200 tanks; 300,000 machine guns and ammunition; 400,000 automatic rifles and ammunition; 1,300,000 regular rifles and ammunition; 380 Navy ships; 200 mercantile ships; 210 camps and cantonments; 40 Government factories; clothing and equipment for 1,200,000; the first mass-production tank factory in the world; 5 smokeless powder and high-explosive plants; 6 shell-, bag-, and ammunition-loading plants; 5 new machine-gun plants, and 50,000 trucks.

Artillery Materiel and Components

Facility	*Amount*
American Locomotive Co., Schenectady, N. Y.	$ 35,090.00
American Type Founders, Elizabeth, N. J.	570,380.00
Brill Co., J. G., Philadelphia, Pa.	189,627.00
Chain Belt Co., Milwaukee, Wis.	2,747,708.00
Colt's Patent Fire Arms Manufacturing Co., Hartford, Conn.	349,329.24
Cowdrey Machine Works, C. H., Fitchburg, Mass.	3,566,800.00
Eclipse Machine Division (Bendix Aviation Corporation), Elmira, N. Y.	3,303,653.00
General Bronze Corporation, Long Island City, N. Y.	102,405.00
Goodman Manufacturing Co., Chicago, Ill.	1,020,215.00
Hobbs Co., Clinton E., Everett, Mass.	25,268.95
Hoe & Co., Inc., R., New York, N. Y.	30,990.00
Lukens Steel Co., Coatesville, Pa.	66,341.33
Milwaukee Saddlery Co., Milwaukee, Wis.	34,388.00
Moto-Scoot Manufacturing Co., Chicago, Ill.	80,119.04
Otis Elevator Co., Buffalo, N. Y.	42,568.54
Peoria Tent & Awning Co., Inc., Peoria, Ill.	25,000.00
Ryerson & Son, Inc., Joseph T., Chicago, Ill.	38,328.50
Seiberling Rubber Co., Akron, Ohio	130,333.00
Standard Machinery Co., Providence, R. I.	141,120.00
Struthers Wells-Titusville Corporation, Titusville, Pa.	238,306.00
Timken-Detroit Axle Co., Detroit, Mich.	172,597.08
United Engineering & Foundry Co., Pittsburgh, Pa.	3,221,294.62
Warner Electric Brake Manufacturing Co., Beloit, Wis.	26,369.96
Wood Manufacturing Co., John, Muskegon, Mich.	169,250.44
York Safe & Lock Co., York, Pa.	1,043,328.00

Ordnance Production Contracts

Artillery Ammunition and Components

Facility	*Amount*
American Brass Co., Waterbury, Conn	$ 834,104.65
Atwater Manufacturing Co., Plantsville, Conn	118,125.00
Bohn Aluminum & Brass Corporation, Detroit, Mich	431,057.10
Bridgeport Brass Co., Bridgeport, Conn	369,425.00
Canister Co., Phillipsburg, N. J	448,764.95
Chase Brass & Copper Co., Waterbury, Conn	759,297.71
Dienelt & Eisenhardt, Inc., Philadelphia, Pa	30,060.00
Eclipse Machine Division (Bendix Aviation Corporation), Elmira, N. Y	187,224.00
Elgin National Watch Co., Chicago, Ill	5,550,000.00
Frost Co., Kenosha, Wis	301,696.00
General Railway Signal Co., Rochester, N. Y	4,375,000.00
Globe Machine & Stamping Co., Cleveland, Ohio	491,000.00
International Harvester Co., Chicago, Ill	108,000.00
Kilgore Manufacturing Co., Westerville, Ohio	267,376.20
National Cash Register Co., Dayton, Ohio	293,948.00
National Malleable & Steel Castings Co., Cleveland, Ohio	147,000.00
Norwalk Lock Co., South Norwalk, Conn	2,910,000.00
Paige & Co., Frank E., Boston, Mass	53,760.00
Peco Manufacturing Corporation, Philadelphia, Pa	359,960.00
Republic Steel Corporation, Cleveland, Ohio	95,904.00
Revere Copper & Brass, Inc., Baltimore, Md	1,107,157.44
Rhode Island Fabrics Co., Pawtucket, R. I	409,546.05
Rose Manufacturing Co., Frank, Hastings, Nebr	206,323.20
Schwitzer-Cummins Co., Indianapolis, Ind	357,875.00
Scovill Manufacturing Co., Waterbury, Conn	8,099,144.00
Somerville Machine & Foundry Co., Somerville, Mass	53,437.36
Standard Pressed Steel Co., Jenkintown, Pa	1,696,412.00
Standard Products Co., Port Clinton, Ohio	109,200.00
Susquehanna Silk Mills, Sunbury, Pa	37,375.00
Tredegar Co., Richmond, Va	129,844.00
U. S. Machine Corporation, Lebanon, Ind	127,000.00

Small-Arms Matériel and Components

American Locomotive Co., New York, N. Y	$ 25,782.24
Barnard Aviation Equipment Co., Ashley, Pa	163,864.00
Bates Shoe Co., Worcester, Mass	1,355,310.28
Bay State Tool & Machine Co., Springfield, Mass	26,982.05
Boyt Harness Co., Des Moines, Iowa	176,910.22
Chicago Graphic Arts Federation, Inc., Chicago, Ill	430,111.34
Colt's Patent Fire Arms Manufacturing Co., Hartford, Conn	11,889,832.98
Cunningham Sons & Co., James, Rochester, N. Y	1,993,620.00
Evans Products Co., Detroit, Mich	1,278,440.88
Firestone Tire & Rubber Co., Akron, Ohio	3,986,340.00
Gilbert & Barker Manufacturing Co., Springfield, Mass	173,390.23
Jackes-Evans Manufacturing Co., St. Louis, Mo	783,000.00
Lamson Co., Syracuse, N. Y	441,000.00
McCord Radiator & Manufacturing Co., Detroit, Mich	958,584.12
McEvoy Co., Houston, Tex	810,360.00
Naragansett Machine Co., Providence, R. I	27,586.70
New House Paper Co., Moline, Ill	63,436.34
Republic Steel Corporation, Buffalo, N. Y	140,149.36
Republic Steel Corporation, Cleveland, Ohio	95,513.00
Sears Saddlery Co., Davenport, Iowa	32,446.00
Seymour Products Co., Seymour, Conn	61,938.88
Stevens & Co., J. P., New York, N. Y	241,800.00

Ordnance Production Contracts

Facility	*Amount*
Stevens Arms Co., Chicopee Falls, Mass.	$ 42,100.00
Stevens Walden, Inc., Worcester, Mass.	47,808.00
Stow Manufacturing Co., Binghamton, N. Y.	36,860.00
Trackson Co., Milwaukee, Wis.	100,791.44
Universal Crusher Co., Cedar Rapids, Iowa	802,410.00
Valley Forge Sales Corporation, New York, N. Y.	35,410.00

Small-Arms Ammunition and Components

American Brass Co., Waterbury, Conn.	$ 1,690,050.60
American Chain & Cable Co., Inc., Bridgeport, Conn.	55,000.00
American Metal Co., Ltd., New York, N. Y.	88,950.00
Bers & Co., E., Philadelphia, Pa.	125,200.00
Bridgeport Rolling Mills Co., Stratford, Conn.	64,450.45
Chase Brass & Copper Co., Waterbury, Conn.	806,926.85
Container Corporation of America, Philadelphia, Pa.	29,600.00
Hershey Metal Products, Inc., Derby, Conn.	106,675.00
Revere Copper & Brass, Inc., Baltimore, Md.	1,460,489.60
Schoettle & Co., Edwin J., Philadelphia, Pa.	308,166.00
Scovill Manufacturing Co., Waterbury, Conn.	96,000.00
Standard Pressed Steel Co., Jenkintown, Pa.	564,199.50
Western Cartridge Co., East Alton, Ill.	33,385.20

Bombs, Pyrotechnics and Components

American Hardware Corporation, New Britain, Conn.	$ 114,495.00
Liberty Display Fireworks Co., Wilmington, Ill.	32,760.00
National Tube Co., McKeesport, Pa.	91,000.00
New Jersey Fulgent Co., Inc., Metuchen, N. J.	639,960.00
Parsons Co., Detroit, Mich.	115,392.50

Powder, Chemicals, and Explosives

Dow Chemical Co., New York, N. Y.	$ 37,950.00
Du Pont de Nemours & Co., Inc., E. I., Carney's Point, N. J.	117,750.00
Du Pont de Nemours & Co., Inc., E. I., Repauno, N. J.	34,240.00
Hercules Powder Co., Kenvil, N. J.	29,150.00

Combat Vehicles, Automotive Equipment, and Accessories

Allis-Chalmers Manufacturing Co., Milwaukee, Wis.	$ 34,266.85
American Car & Foundry Co., Berwick, Pa.	63,196.80
Anthony Co., Streator, Ill.	27,956.50
Autocar Co., Ardmore, Pa.	40,775.90
Continental Motors Corporation, Detroit, Mich.	47,944.00
Eclipse Aviation Division (Bendix Aviation Corporation), Bendix, N. J.	1,010,549.75
General Steel Castings Corporation, Eddystone, Pa.	26,500.00
Goodrich Co., B. F., Akron, Ohio.	5,780,100.00
Guiberson Diesel Engine Co., Chicago, Ill.	4,356,610.63
International Harvester Co., Chicago, Ill.	361,375.18
Rockford Drilling Machine Co., Rockford, Ill.	165,474.71
Seiberling Rubber Co., Akron, Ohio.	69,896.68

Ordnance Production Contracts

Fire Control

Facility	*Amount*
Delco Appliance Division (General Motors Corporation), Rochester, N. Y.	$ 2,589,809.25
Eastman Kodak Co., Rochester, N. Y.	3,710,016.87
Elgin National Watch Co., Elgin, Ill.	265,953.75
Friez & Sons Division, Julien P. (Bendix Aviation Corporation), Baltimore, Md.	25,000.00
Hobart Manufacturing Co., Troy, Ohio	51,343.30
Marine Division (Bendix Aviation Corporation), Brooklyn, N. Y.	78,710.00

Tools and Machinery

Bullard Co., Bridgeport, Conn.	$ 299,815.70
Canister Co., Phillipsburg, N. J.	34,000.00
Cincinnati Gilbert Machine Tool Co., Cincinnati, Ohio	28,650.00
Clearing Machine Corporation, Chicago, Ill.	27,700.00
Denison Engineering Co., Columbus, Ohio	180,525.00
Detroit Broach Co., Detroit, Mich.	44,868.00
Duriron Co., Inc., Dayton, Ohio	140,000.00
Exact Weight Scale Co., Columbus, Ohio	206,584.70
General Machine Co., Newark, N. J.	44,974.00
Gibbs & Co., Inc., Thomas B., Delavan, Wis.	354,832.00
Hanssen Sons, Louis, Davenport, Iowa	38,520.00
Lees-Bradner Co., Cleveland, Ohio	74,988.70
Logansport Machine, Inc., Logansport, Ind.	250,830.00
McKiernan-Terry Corporation, Dover, N. J.	128,846.00
National Acme Co., Cleveland, Ohio	1,971,330.00
National Broach & Machine Co., Detroit, Mich.	26,316.00
Ogden Iron Works Co., Ogden, Utah	48,950.00
Pacific Foundry Co., Ltd., San Francisco, Calif.	71,200.00
Pratt & Whitney Division (Niles-Bement-Pond Co.), West Hartford, Conn.	72,459.00
Prentiss & Co., Henry, New York, N. Y.	49,620.00
Quality Hardware & Machine Corporation, Chicago, Ill.	38,097.00
Read Machinery Co., Inc., York, Pa.	74,227.20
Riordan Machinery Co., Detroit, Mich.	31,348.00
Roessler Machine Co., Elkins Park, Pa.	34,611.00
Sheffield Gage Corporation, Dayton, Ohio	125,000.00
Veit & Young, Philadelphia, Pa.	63,841.00
Vulcan Mold & Iron Co., Latrobe, Pa.	25,561.55
Watson-Stillman Co., Roselle, N. J.	363,075.00

Gages

Allegheny Ludlum Steel Corporation, Brackenridge, Pa.	$ 41,900.00
Greenfield Tap & Die Corporation, Greenfield, Mass.	51,557.45
Hanson-Whitney Machine Co., Hartford, Conn.	75,497.81
Modern Tool & Die Co., Philadelphia, Pa.	100,614.00
Pennsylvania Tool & Manufacturing Co., York, Pa.	35,267.00
Pratt & Whitney Division (Niles-Bement-Pond Co.), West Hartford, Conn.	76,746.46
Precise Tool & Manufacturing Co., Farmington, Mich.	230,079.90
Precision Manufacturing Co., Philadelphia, Pa.	51,086.00
Schlosser Manufacturing Co., Philadelphia, Pa.	77,493.00
Vinco Corporation, Detroit, Mich.	39,243.60
Wyoming Tool & Die Co., Philadelphia, Pa.	29,380.00

Aircraft Armor

The Protection of Flying Personnel from Hostile Fire

Horace J. Alter*

THE strategic value of the airplane as a military weapon was discovered soon after its first successful flight. Its value as a long-range artillery weapon exceeds that of any gun in efficiency and destructive effect. The continued development of bomber and pursuit has resulted in a race similar to that which goes on between armor-plate and projectile manufacturers. Each seeks to develop a better airplane to force the other out of the sky. Every means to keep the airplanes flying is used, and protection for personnel and equipment is now provided on all fighting airplanes.

Steel plate as a protective covering has been used for over a century and a half, but the development of light armor plate 1 to 1½ inches or less thick has been limited to the years following the World War. It was developed during that conflict for use on tanks and armored cars, and its continued development has followed the demand for increased speed in these vehicles, which requires light plate. Soon after airplanes were flying over the Western Front, pilots were asking for something to protect the seat of their pants against the fire of ground troops and something at their backs to protect them from the hostile airplanes on their tail. They used stove lids, gun shields, car doors or any piece of heavy metal lying around loose. The development of armor plate for aircraft use soon followed, but the work was not continued in the years following the close of the war.

Armor is used to protect the airplane's operating personnel and vital flying and fighting equipment. Service tests prove that a combat crew trained and working together reaches a high degree of efficiency. The loss of a member of the crew is followed by a decrease in efficiency and a temporary reduction in morale. Important mechanisms, bombing apparatus, electrical equipment, etc., must be protected in order that the airplane may fulfill its mission against all obstacles. The fuel and oil tanks must be protected to sustain flight and prevent explosions. Protection also must be provided for the electrical, hydraulic, and control systems. The use of protective armor has a marked effect upon the psychology and morale of the combat crew by relieving the nervous tension and strain which exist when the crew is exposed to direct machine-gun and cannon fire.

Airplanes may be subjected to several different types of ammunition fire. They may be fired upon by ground troops, antiaircraft batteries, and hostile airplanes. Ground troops use caliber .30 or .50 ball, tracer, and armor-piercing ammunition, depending upon the type of weapon used. The guns of hostile aircraft may use caliber .30 or .50 ammunition or light cannon with 20- or 37-mm. explosive shells. Three- to five-inch shells are used by antiaircraft batteries, and it is entirely feasible that airplanes may soon carry cannon of large bore.

The modern airplane is so constructed that little if any serious damage can be done to the structure by small-bore ammunition. In some cases the structure has survived hits by large shells and the airplane has still continued in flight. However, since the structure and covering of the airplane is not sufficient protection for personnel and equipment against small-bore ammunition and shell fragments, additional means in the form of armor plate must be added.

Attacks on the airplane can be launched from several directions simultaneously, but it cannot be attacked by more than one airplane at a time from any one direction. Hostile aircraft attack may be complemented by antiaircraft and ground-troop fire. Aircraft attacks are most probable from the rear hemisphere, from about fifteen degrees below to about forty-five degrees above the horizontal. With the advent of the multiseat fighters, attack from the forward lower hemisphere is feasible. Antiaircraft fire from large guns may be effective in any direction, but usually strikes from below. It is essential that the crew and mechanisms be protected from as many directions as possible.

THERE are certain advantages which occur and which may be taken into account when designing armor plate for airplanes: (1) The major portion of gunfire is directed at angles less than normal to the surfaces of the airplane; (2) The relative distance between airplanes in combat allows the pilot time to maneuver away from the fixed guns of an opponent; (3) The speed of the airplane relative to the speed of the bullet and rate of fire of the gun is so high as to give a wide dispersion of hits and the spacing between shots is increased as the ratio of speeds increase.

The formula for the penetration of a projectile into a solid body was first defined by Petry and later used in different forms by the Krupp Iron Works and the French ballistics expert De Marre. It may be expressed by the general relationship: $E = M\, d^m\, S^n\, f(a)$, where E equals the striking energy of the projectile; d, the caliber of the projectile; S, the depth of penetration of the projectile or the thickness of the plate; M, the resistance of the plate; a, the angle of impact of the projectile; and where m and n are coefficients expressing the resistance of the section and the resistance of the surrounding material respectively.

Since the striking energy is expressed by the equation $E = \frac{M\ V^2}{2}$, the importance of striking velocity is out of proportion to that of mass. It is seen that, given sufficient velocity, ordinary ball ammunition will penetrate armor plate as readily as armor-piercing. The particular velocity at which a plate just resists penetration by the bullet is called the ballistic limit of the plate. Penetration is also dependent upon the striking angle of the bullet—penetration being greatest at normal angles of impact and least when the angle of impact approaches zero.

It is seen from these formulas that the attacking airplane controls three factors which affect the penetration of the projectile; namely, (1) The velocity of the bullet, determined by the powder charge and length of the gun barrel; (2) The caliber of the bullet, determined by the bore of the gun, which is indirectly influenced by the size of the airplane; (3) The weight and thus the trajectory of the bullet.

The factors which the attacked airplane controls and which

*Aëronautical engineer, Normandy, Mo.

can be designed into the airplane by the armor plate designer are: (1) The thickness of armor plate; (2) The type of plate and its ballistic properties or resistance; (3) The angle of impact of the bullet upon the plate. This is determined by figuring from which angles the airplane is most likely to be attacked.

IN THE design of plate for aircraft use, advantage may be taken of the fact that penetration under glancing impact is resisted by thinner plate than under normal impacts. The effect of impact at normal angles is limited to an area approximately three calibers in diameter, thus putting a high stress in the plate. Under the glancing impact, the effect is distributed over an area from two to five calibers long by two to three calibers wide, depending upon the bullet-impact angle. The effect of tumbling or turning the bullet is to increase the angle of impact.

If it is assumed that the resistance of the plate is the maximum obtainable, the thickness of the plate varies for different sections of the airplane. The gauge of plate is proportional to the angles at which the plate is mounted. For armor installed on the upper surface of the wing, where the angles of impact are more likely to be zero, the plate will be thin, while for a section at the rear of the fuselage, where the bullets will strike at more normal angles, the plate will be thick. Where the bullets are likely to pass through structure or equipment before hitting vital parts or personnel, advantage may be taken of the tumbling effect of the member and a thin plate installed.

There are two general types of light steel armor plate. First, there is a face-hardened plate in which the face exposed to gunfire has a greater hardness and resistance to penetration than the remainder of the plate. The exposed face is heat-treated and hardened to give a compact physical structure, while the remainder of the plate is made very tough and ductile. These plates show little tendency to crack, spall, or throw buttons off the rear of the plate when struck by projectiles. Several tests run on this type of plate prove it superior for thicknesses of three-eighths of an inch and over. Its use in aircraft presents several difficulties, among which are the heat treatment, resistance to forming, and the warping out of shape due to difference in grain structure and temperature of heat treatment. For plates less than three-eighths of an inch thick, the face-hard plate shows little if any advantage for aircraft use.

Then there is homogeneous plate—a type which has a uniform and consistently hard and compact structure from face to rear. In some cases, ductility and toughness are sacrificed to secure good ballistic properties. The plates show tendencies to throw buttons, spall, and shatter when subjected to bursts of machine-gun fire due to the vibration which is set up in the internal molecules of the plate. Since aircraft plate would not be subjected to concentrated bursts, vibration and shattering are not likely to occur. As previously pointed out, the dispersion of hits is such that no two shots are usually closer than eight inches. Homogeneous plate is more suitable for aircraft use than face-hardened plate since it can be formed to contours, has a simple heat treatment, less manufacturing losses, and in general is easier to fabricate.

Present combat ranges for airplanes are approximately one hundred yards or more. Homogeneous or face-hardened plate one-quarter of an inch thick will stop complete penetration of a caliber .50 armor-piercing bullet when the angle of obliquity, the angle between the flight path of the bullet and a normal to the plate, is sixty-five degrees or less. One-half-inch plate will stop armor-piercing caliber .50 bullets at twenty degrees. Good plates of either type shatter the projectile without appreciable signs of cracking or shattering. Most of the armor-piercing cores break into small fragments upon striking the plate.

There have been several types of composite plate, and their development offers possibilities of saving weight. On the other hand, they are bulky, require more space, and have assembly and construction or installation difficulties. Specially shaped plates which reduce the penetration by means of blisters, pyramids, or curved surfaces are feasible.

Flexible mountings, such as springs or rubber pads, show little or no improvement and may be injurious by producing a racking effect; that is, tearing the plates loose from their fastening bolts. The racking of plates is barely perceptible at normal angles, but as the angles of obliquity increase, the racking effect grows more pronounced.

BULLET-PROOF glass is also used for armoring purposes. The hard surface of glass makes it a good protective plate. Bullet-proof glass is used in airplane windshields where the angle of impact is very low, about forty-five degrees or less, and where a glancing blow causes the bullet to ricochet. When the bullets strike at angles more nearly normal, the surface is starred and the glass powdered or splintered and slivered. The bullet core is imbedded between the layers of glass and the plastic binder. The area affected varies from six to ten inches, although visibility is still possible through the outer regions of the affected area.

Bullet-proof glass two inches thick will stop penetration of caliber .30 ball ammunition at normal impacts. Glass three inches thick will stop caliber .50 bullets. There is little difference between the penetration of ball and armor-piercing ammunition, the surface of glass being so hard that splintering and powdering takes place, and the penetration of the bullet is stopped by the increased friction. Since windshields always are sloped for good streamlining, the bullets will hit at angles less than normal.

Armor plate should be installed so that it is accessible for replacement or repair in case penetration or cracking occurs. A weight comparison should be made between thin plates installed at critical angles and thick plates at normal angles in order that plate of minimum weight may be installed. By placing the plate close to the object to be protected, a reduction in the required area of plate is possible. The area needed for protection varies directly as the square of the distance from the object to the plate. Auxiliary equipment can be installed to serve as protection and baffles for tumbling the bullet, thus allowing thinner plate to be installed. For example, the nose wheel may serve to protect the pilot against gunfire from below, the main landing wheels as protection for the oil or fuel tanks, etc. By centralizing vital mechanism and personnel in specific areas they may be protected with one piece of armor.

Armor in the pilot's compartment should protect his head, back, and seat. Bullet-proof glass should protect him from fire coming from the forward hemisphere. Where possible, all equipment in the pilot's compartment should be placed to form protection and baffles. It must be remembered that a preponderance of attacks are most likely to occur from the rear at angles normal or nearly normal. It is essential that plate protecting against gunfire from this quarter be heavier than that protecting against gunfire from the forward quarter.

ARMY ORDNANCE

Founded 1920

Published Bimonthly by
THE ARMY ORDNANCE ASSOCIATION
WASHINGTON, D. C.

Col. J. L. Walsh, Founder and Editor, 1920-1922
Brig. Gen. R. H. Somers, Editor, 1922-1925
Brig. Gen. R. L. Maxwell, Editor, 1925-1926
Col. C. R. Baxter, Editor, 1926-1929

Managing Editor: Lieut. Col. L. A. Codd, Ord. Res.
Associate Editor: R. E. Lewis, Jr.
Editorial Staff: Lieut. Col. C. H. Goddard, Ord. Res., F. G. Ferriter, H. E. Allen, F. W. F. Gleason.

MARCH-APRIL, 1941

Month by Month

DOMINATING HIGH LIGHTS IN THE INDUSTRIAL mobilization scene are (1) the generally satisfactory rate of progress in the attainment of ordnance goals, both in men and equipment, and (2) the sound character of the new organizations for defense production. While both may be spotty in parts they are, by and large, encouraging. The men and the machinery of defense production are gradually being geared to full speed. Particularly is this true in the new organization of the Office of Production Management. The O.P.M. has as its director-general William S. Knudsen; as associate director-general, Sidney Hillman; and as members, the Secretary of War, Henry L. Stimson, and the Secretary of the Navy, Frank Knox.

The O.P.M. is divided into three major divisions: production under John D. Biggers, purchases under Donald M. Nelson, and priorities under Edward R. Stettinius, Jr. This new organization is streamlined to fit the needs of the day. It offers considerable improvement over the more cumbersome organization which prevailed in the National Defense Advisory Commission. It is decidedly a step in the right direction but is weak in that final authority is not in one man but in two. It is difficult to see how optimum results can be obtained where the command is not unified. Time will tell!

The entire Army, as now planned, of 1,418,097 enlisted men will be in camp by June 1, 1941, fully housed with all its personal equipment and with basic weapons enough for training purposes. By that date, it is expected that a total officer personnel—Regular, National Guard, and Reserve—to the number of 97,371 will be serving with the colors. Obviously, modern equipment sufficient for battle needs for this large force will not be available. Balanced production in sizable quantities for the present program will not come in until late 1941 and early 1942. In other words, the time-lag for balanced mass production of ordnance—*as has been repeatedly harped on here to the chagrin of the uninitiated*—is somewhere between eighteen months and two years from scratch.

For the new Army now in training there will be no shortage in uniforms, shoes, blankets, and other personal equipment. Nor will there be any shortage of basic weapons such as rifles, pistols, caliber .30 machine guns, and certain types of artillery. But other newer types of weapons will not be available in sufficient quantity although there will be enough for training. The principal lack will be in aircraft, and in this field quantities available will depend very greatly upon our national policy with regard to supplying England in her present need.

March 1941 marks the sixth month since the beginning of the present accelerated armament production program. This program was begun not in the spring or summer of 1940, but in reality in September of last year, when the Congress finally gave the signal to go. At the end of six months the country can take heart at what the Army, Navy, and industry have been able to do in so short a time. In many, many instances, quantity production of certain types of equipment is well under way; in other cases where new facilities and new construction are required on a tremendous scale, progress is good, but final results in the form of finished products cannot be gotten for many months to come. Artillery ammunition cannot be gathered out of thin air; howitzers and tanks do not grow on trees. With the best of intention and the finest skill, the job of building new plants and revamping old ones takes time. And for time there is no substitute. What counts most at the moment is the rate of progress. Gauging the situation in its broad outline and regardless of insurmountable delays in one direction or another, the picture in wide perspective is decidedly encouraging.

BACK OF ALL THIS ARE THE SPLENDID ORganizations which the Army and Navy have had for many years operating with American industry. In particular, the Ordnance system of decentralized control, shown visually on the map and in explanatory data published in this issue of ARMY ORDNANCE, has proved its value a hundred times over in the present emergency. Informed opinion on this subject is quite unanimous that Ordnance leadership more than any other factor in the United States has, through its policies of the last twenty years, brought about a condition which is largely responsible for the successful results now being achieved.

But the Ordnance objective is only one need of a much larger production demand. Hence it is that all students of industrial preparedness can acclaim the splendid organization which Mr. Knudsen has brought together in the division of production in the new Office of Production Management. Readers of this journal should be familiar with the Production Division, for upon the close degree of coöperation between its personnel and Ordnance personnel—both in

Government and private manufacturing plants—will depend the real success of the present armament effort.

Immediately under Mr. Knudsen, as director general of production management, is John G. Biggers, director of the Production Division. Mr. Biggers, on leave from the Libby-Owens-Ford Glass Company, of which he is president, has served for the past seven months as Mr. Knudsen's deputy on the National Defense Advisory Commission. The following gentlemen are on Mr. Bigger's staff:

William L. Batt, deputy director.—President, SKF Industries, on leave; for the past seven months deputy commissioner of the Industrial Materials Division of the Advisory Commission.

W. Averell Harriman, chief, industrial materials.—Mr. Harriman is on leave as chairman of the board of directors of the Union Pacific Railroad, and for the past seven months has been liaison officer of the Industrial Materials Division.

E. F. Johnson, chief, aircraft, ordnance, and tools.—Mr. Johnson was formerly vice-president of General Motors Corporation and for the past seven months has been the director of the light-ordnance section of the Production Division.

W. H. Harrison, chief, ships, construction, and supplies.—Mr. Harrison is on leave as vice-president and chief engineer of the American Telephone & Telegraph Company, and for the past seven months has been chief of the construction section of the Production Division.

George M. Moffett, chief, mining and mineral products.—Mr. Moffett is on leave as president of the Corn Products Refining Company and for the past seven months has been director of the food-products section of the Production Division.

R. R. Deupree, chief, agriculture and forest products.—Mr. Deupree is on leave as president of Procter & Gamble Company and for the past two months has been division executive of agriculture and forest products.

E. R. Weidlein, chief, chemicals, drugs, and allied products.—Dr. Weidlein is on leave as director of the Mellon Institute and has been division executive of chemicals and allied products of the Industrial Materials Division.

Merrill C. Meigs, chief, aircraft.—Mr. Meigs is on leave as publisher of the Chicago *Herald-American* and for the past two months has been director of the aëronautical section of the Production Division.

A. R. Glancy, chief, ordnance.—Mr. Glancy was formerly president of the Pontiac Motor Company and has been a special adviser to the ordnance section of the Production Division.

Mason Britton, chief, tools.—Mr. Britton is on leave as vice-chairman of McGraw-Hill Publishing Company and for the past three months has been director of the machine-tool section of the Production Division.

Adm. Emory S. Land, chief, ships.—Admiral Land is chairman of the Maritime Commission and for the past seven months has been director of the shipbuilding section of the Production Division.

J. C. Nichols, chief, supplies.—Mr. Nichols is on leave from J. C. Nichols Investment Company of Kansas City, Mo., and for the past seven months has been director of the miscellaneous equipment section of the Production Division.

The significance of these and other armament developments was best summarized in the words of Gen. George C. Marshall, Chief of Staff of the Army, speaking at the annual dinner of the National Aëronautic Association in Washington recently. General Marshall called attention to the fact that today we are in many ways at the critical point in a great transition from a condition of more or less complete unpreparedness to one of tremendous military power. We are confused by statistics and by unrestrained public debates over each difficulty or delay. "Every move that we make is subjected to the closest scrutiny and every error, real or imaginary, is pounced upon and exploited to the world. This welter of conflicting information has so confused the public mind," General Marshall said, "that few realize either how much has been done, or how much remains to be done. And I might say in this connection that we are very fortunate in having men at the head of our Army air activities who are veterans of the art and pioneers of our military air force. . . . They (our people) are requiring the development of a huge air force; they have endorsed a vast munitions program. They are insistent that we make haste in our preparations. In other words, the people of this country are declaring to the world, in a positive manner, their intentions to defend the integrity of this hemisphere and of this particular country at all costs."

A TIMELY AND IMPORTANT STEP WAS TAKEN by the War Department in mid-January when the Secretary of War, Mr. Stimson, announced the appointment of a committee of seven engineers, each representing a national engineering organization, to assist the War Department in technical matters relating to the collection, evaluation, and dissemination of information of value in the protection of civilians and vital civilian installations in time of war.

The members of the committee, which will be known as the National Technological Civil Protection Committee are: Walter D. Binger, American Society of Civil Engineers, chairman, of New York, N. Y.; W. H. Carrier, American Society of Heating and Ventilating Engineers, of Syracuse, N. Y.; Harry E. Jordan, American Waterworks Association, of New York, N. Y.; A. B. Ray, American Institute of Chemical Engineers, of New York, N. Y.; Abel Wolman, American Public Health Association, of Baltimore, Md.; James L. Walsh, American Society of Mechanical Engineers, of New York, N. Y. (founder and first editor, 1920-1922, of ARMY ORDNANCE); Scott Turner, American Institute of Mining and Metallurgical Engineers, of New York, N. Y.

This committee of national figures in the engineering world may be enlarged from time to time as conditions warrant. As now contemplated, the committee will work within limits to be defined by the Secretary of War, which will obviously be subject to amendment as conditions change. The engineering organizations represented on the committee, as well as others, both regional and national in scope, will furnish to the War Department through this committee technical information that the committee deems of value to the War Department and to the nation in matters concerning the protection of the civilian population from air and other attack in time of war. The War Department in turn will furnish the committee with pertinent information of the very latest successful methods employed abroad to safeguard civilian communities against air and other attack. Among the problems to be studied will be those pertaining to air-raid bomb shelters, water supply, and power.

Mr. Stimson announced at the same time that Maj. Eugene W. Ridings, of the War Department General Staff, had been designated as the liaison officer for the committee.

The Road Ahead

An Editorial

IF all the past is prologue then the future of military armament in the United States will give thinking men cause for concern. What is being done now—haltingly at times, magnificently at others, and even stupidly on occasion—will leave its mark not alone upon our national well-being and not only upon our concept of hemisphere defense but also upon our very existence as a military power in a world where military power bids fair to control for a long time to come. It is now time to appraise what we are doing for our defense in terms of the years that lie before us. The armament epilogue must be different from anything we have done in this regard in the past.

Our old mistakes can be restated under three headings: 1. Being a peaceful people, we have misjudged the function of armaments as a force for peace. 2. Being a non-militaristic people, we have misjudged the function of the soldier as a force for order. 3. Being a gullible people, we have misjudged the function of the demagogue as a force for disorder. Strangely enough, these misjudgments, collectively, have determined our armament status in the past.

Already signs are clear as to first steps which should be taken along the armament road which lies ahead—if old failures are not to be repeated. The first move lies in the broad field of *economic defense*. The second relates to our *armament production capacity*. The third is in the realm of a *revitalized doctrine of industrial preparedness*. No one of these steps is more important than the other. Properly integrated, they form a team of armament defense in the modern sense which, given American genius and fair play, can help shape our national future.

Economic defense is now accepted as a component of military strategy. This acceptance is a victory because heretofore the military mind was not greatly conscious of economic defense and the civilian mind was even less so. What with the increasing effect the control of exports is having upon our own military strength, it is difficult to believe that this new doctrine will recede as an accredited method of national security in the years that lie ahead. The present indication points to the need for a permanent body of skilled experts to study the ramifications of economic defense at all times and under all conditions. Further, a school where the doctrines of economic defense will be taught both to military and lay students is already an obvious need. At the moment, our policies have in mind simply the defense of our own interests; modern warfare indicates that national policy expand also into the field of the offense.

Coequal with economic defense in modern war is the doctrine of adequate production capacity, that is to say, adequate armament production capacity.

ELSEWHERE in this issue the map showing new production capacity for noncommercial items of Ordnance speaks for itself. It is intended to present in broad outline the facilities now under construction to augment the very meager production capacity for specialized ordnance equipment which existed in the United States until recently. Heretofore, the six manufacturing arsenals operated by the Ordnance Department of the Army and a smaller number of similar establishments operated by the Navy have been looked upon as repositories of the art of armament production. Here the necessary techniques connected with the design, manufacture, and operation of new weapons have been developed. Here personnel have been trained.

The arsenals have lived up to expectations magnificently. Their place in our national-defense economy must remain secure under all circumstances. They must continue to be the repositories of the armorer's art and they must, above all, continue to train and send forth artisans who are equipped to teach private industry its defense job. But private industry has no adequate counterpart for certain types of ordnance manufacture. These types comprise principally artillery ammunition, small-arms ammunition, and bombs, the consumption of which in time of war staggers the imagination. Therefore, the simplest kind of good sense dictates that the production capacity now being provided for the manufacture of smokeless powder and military high explosives, for the loading of these substances into ammunition and bombs, for the storage of this matériel at strategically located centers and for the production of such other equipment (*e.g.*, armor plate, tanks, etc.) be kept indefinitely—one might almost say in perpetuity.

Armament production capacity *in being* can be responsible for victory in modern war. In our own case, the permanency of this new capacity must become an objective to which the Army Ordnance Association and other like-minded societies and individuals can devote their energies. As was said in this place in the last issue of ARMY ORDNANCE, it must never again happen that our new plant capacities or that our new production facilities for the manufacture of noncommercial items of ordnance be ruthlessly scrapped as was done after the World War.

AND finally there is industrial preparedness. It is no new thing to say that industrial preparedness is not static. In the days when the Industrial Mobilization Plan was frowned upon by nine out of ten American citizens as being a step toward "dictatorship" and a political instrument, it was customary to reply that the I.M.P. was neither dictatorial nor political. Surely it is not static. Never a day in the armament of democracy but that new lessons are taught. The new lessons must be incorporated in the accepted doctrines and—most important of all—they must be learned *as we go*.

It can be said with the greatest of truth that industrial mobilization during the past twenty years has come a long way. Today it is paying sizable dividends. In the words of Maj. Gen. C. M. Wesson, Chief of Ordnance, in a recent address: "In point of time we are at least six months ahead of our record of the World War. In contracts placed we are at least 500 per cent ahead. This is exactly as it should be, because we have been studying for twenty years how to handle an emergency program, and, if we are not far ahead of the commensurate World War record for which there was little advance planning, then indeed have our plans been in vain."

The markings along the road to a balanced armament defense are clear and distinct. Alert minds will not fail to read them; brave souls will not hesitate to learn them; loyal hearts will not falter to obey them. L. A. C.

Association Affairs

Los Angeles Post

THE Under Secretary of War, Hon. Robert P. Patterson, was the guest of honor and the principal speaker at the annual meeting of the Los Angeles Post, Army Ordnance Association, at the University Club, Los Angeles, on the evening of January 27, 1941. More than 400 members and guests of the Post were in attendance. Earl B. Gilmore, president of the Post, presided. Judge Patterson took as the keynote of his address the satisfactory progress now being made by private industry and by Government establishments on the production of armament.

"I am happy to report to you," he said, "that the defense situation is not nearly so black as some people try to paint it. The War Department always has maintained that eighteen months would be required to get things going full blast—eighteen months dating from the fall of France last spring, which first awakened us to the size of the peril that is loose in the world. That eighteen months is not a figure which was picked out of a hat. It represents a sound conclusion based on our World War experience and on our understanding of the industrial potentialities of America."

Emphasizing the vital importance of production capacity for critical items of armament, Judge Patterson said: "Once we have capacity we can get all the production we want when we want it, and we can lay in stock at will, almost without regard to a deadline that is actually a life line.

"Our tank situation offers a striking practical example of this principle. We used two types of tanks in the World War, 6-ton and 30-ton. Of the 6-ton, we had produced in this country, up to the Armistice, a total of 64, and we kept right on producing them until at the end of March 1919, we had 778. But for our actual battle participation, we depended on the French who provided 227 of the light vehicles for us. Our 30-ton tanks of war days represented, theoretically, an example of inter-Allied coöperation. We were to manufacture the motors and driving mechanism and the British were to manufacture the armor plate. The goal was 1,500 vehicles, for use in a 1919 campaign that did not have to be fought. Almost half of America's share of this joint endeavor had been completed by the Armistice. But for real fighting on the Western Front, so far as heavy tanks were concerned, we depended on the British, from whom we received 64 vehicles.

"We actually used, therefore, not quite 300 light and heavy tanks combined in our battle participation in France. Compare this with the 2 armored divisions we are now organizing—the forerunners of others to come—each of which will be equipped with 287 light tanks and 110 medium tanks, plus 275 heavily armored scout cars for reconnaissance.

"Today we have contracted for one thousand 25-ton tanks to be manufactured at the tank arsenal which is being built at Detroit by the Chrysler Corporation at a cost of $20,000,000. This plant is more than a quarter of a mile long and nearly a tenth of a mile wide, and covers a ground space of nearly sixteen acres. Construction of this enormous structure is ahead of schedule, despite adverse weather conditions which would not be tolerated for a moment in southern California! The thousand tanks to be produced at this arsenal will cost $33,500,000. At first we expected to start production on these tanks next October. Actually they will be rolling off the line in the summer. And I mean the summer of 1941!

"There comes a time when we must say: 'This is the design we are going to follow. On this basis we are going into production. The design may be improved tomorrow. If we can, we will change it. If the change would cause too great a delay, we will not make the change. Better a ninety-eight per cent perfect airplane in existence than a one hundred per cent perfect airplane on paper.'

"Any of us can appreciate the difficulty of standardizing on many models today. Every day new lessons in design reach us from Europe. The competition for supremacy is continually developing new tricks on both sides in the present war, and it is obviously to our great benefit that we are able to take advantage of this situation. We would lose that advantage if we went into tremendous mass production. The self-sealing gas tank, increased armament, heavier armor—we are able to dovetail all these into our airplane adjustments and make more effective fighting ships, better bombers. A too-early standardization of types would lose us the fruits of this free laboratory that Germany and England are operating for us.

"At the end of last October, slightly more than 70,000 workers were engaged in aircraft production in southern California. Next month that figure will have risen to 109,000. By next August it will reach a peak of nearly 125,000. Right now you are employing in this area more than half of the total number of men engaged in aircraft production in the United States. In the nation, when production is at its peak, we shall employ in excess of 450,000 workers in the aviation industry.

"The question of the deferment of skilled workers in the operation of the Selective Service Act has been the subject of frequent and lengthy discussion between officials of the Selective Service system and the office of the Under Secretary of War. My office is charged with supervision of the procurement program—with setting in motion and keeping in motion the machinery that equips and maintains our Army in the field. Both the procurement program and the Army require man power—the one to produce, the other to use. There is no point in training a soldier unless you can arm him—indeed, until he is armed he is not a soldier.

"We cannot set up sharp class distinctions between these two groups. Nothing could be more destructive of morale, and morale means as much to an army as armament itself. We must and shall avoid duplicating the silk-shirt era of 1918. We must and shall avoid repetition of the *opera bouffe* of the shipyards. We are not going to play one group of men against another, any more than we are going to let still a third group wax fat on the toil of the man at the lathe or the man in the Army. The demands of the national defense itself must have precedence over every individual and every group. Our larger, national, unselfish interests, as well as our pettier, personal, selfish interests, require just that. Both labor and management can render a particularly signal service in furtherance of the national-defense program by keeping a steady supply of men in training for skilled jobs with the very purpose of avoiding, so far as possible, any such factor as industrial deferment. But some men may have to remain and forego the privilege of serving in the ranks. They must realize that patriotic service can and must be performed behind as well as in the lines—the English worker knows that behind-the-lines service can be just as nerve-wracking. And the decision where a man can best service his country must rest with his own community, and its representatives on the local board.

"It takes everybody to do a job the size of the present one. It is not just a question of big plants and big organizations and big facilities. The big establishment has to pass on much of the load. If it could not pass it on, stagnation would result. The whole program would be blocked. It would be like the old fable of the lion and the mouse."

Seated at the speakers' table with the honored guests and Mr. Gilmore were: Lieut. Gen. John L. DeWitt, commanding the Fourth Army; Dr. Robert A. Millikan, chairman, executive council, California Institute of Technology; Maj. Gen. Walter P. Story, commanding the 40th Division, California National Guard; Maj. Gen. Ernest D. Peek, commanding Ninth Corps Area; Maj. Gen. Jacob E. Fickel, commanding Southwest District; Joseph A. Hartley, president, Los Angeles Chamber of

Commerce; Col. Kenneth B. Harmon, executive officer, San Francisco Ordnance District; Capt. R. B. Coffman, assistant commandant, 11th Naval District; Col. Roland W. Pinger, Ordnance Officer, Ninth Corps Area; Warren Ege, legal advisor to the Under Secretary of War; Col. Allen Kimberly, commanding officer, Fort MacArthur, and Lieut. Col. A. R. Ginsburgh, aide to the Under Secretary of War. Arrangements for the meeting were made by Maj. Ralph Cook Scott, secretary of the Post, and Frank B. Cole, assistant secretary. Others who served on the committee of arrangements were—in addition to Mr. Gilmore, Major Scott and Mr. Cole—Donald Douglas, vice-president of the Post, and the following directors: W. H. Adams, Ralph O. Cragin, H. S. Hitchcock, M. A. Koffman, and M. M. Mitchell.

BIRMINGHAM POST

MEMBERS of the Birmingham Post, Army Ordnance Association, united with the Chamber of Commerce of Birmingham for the annual meeting of the latter organization, in honor of Maj. Gen. C. M. Wesson, Chief of Ordnance, who was the principal speaker at the meeting held at the Thomas Jefferson Hotel, Birmingham, Ala., January 31, 1941. John F. Coleman, president of the Birmingham Chamber of Commerce, was toastmaster. General Wesson was introduced by Col. Theodore Swann, chief of the Birmingham Ordnance District and president of the Birmingham Post. Hon. Frank M. Dixon, Governor of Alabama, also was an honor guest and spoke in welcome to General Wesson. Nearly 600 members and guests were seated at dinner. General Wesson spoke on "Our Growing Military Strength."

"Slightly more than $6,500,000,000," General Wesson said, "have been made available by the Congress for the military-armament program during the present fiscal year. Of the total, nearly $2,000,000,000 is for Ordnance. Only the Air Corps, with $2,200,000,000 exceeds Ordnance. Third is the Quartermaster Corps, with $1,320,000,000. This is a tremendous national program—tremendous in dollars, in effort, and, in the long run, tremendous in security. These figures fall easily from the lips, so it is appropriate to pause a moment and consider just what they represent: They represent the greatest peace-time program, of national defense or of anything else, that this country has ever attempted. Our Ordnance appropriations, for example, are approaching World War Ordnance expenditures. I mention this to emphasize the seriousness of our effort and the earnestness with which we have embarked on this program. There is no parallel for it in the history, not alone of our country, but of any other.

"Alabama itself will become the arsenal of the South. The ammunition storage depot at Anniston, the powder plant and bag-loading plant at Childersburg, and the great shell-forging and machining plant at Gadsden, will together constitute one of the most formidable contributions to the Ordnance program. In aviation you will have, or already have, Maxwell Field, the single-engine school at Selma, the elementary flying school at Tuscaloosa, and the training center at Tuskegee. At Fort McClellan you are host to 21,000 Yankees who know of your prowess on the fields of France 23 years ago. These men are mostly from New York, and the fathers of some of them, as members of the old 69th Regiment, fought beside your own 4th Alabama as the Rainbow Division forced the enemy back from the Marne across the Ourcq to the Vesle, and in the fiery furnace of the Meuse-Argonne.

"This is an all-American program; a border-to-border, coast-to-coast, ocean-to-ocean program. Right now, for example, more than half our airplane effort, computing by number of workers employed, is concentrated in southern California. Within a few months, this technical center of population will have shifted eastward into the Mississippi Basin. The Pacific Northwest is busy, the Plains States are busy, and, of course, Detroit, the nerve center of the automotive world, is throbbing with tremendous activity.

"New England is busy. At Springfield Armory in Massachusetts we are turning out the new Garand semiautomatic rifle by the thousand. Springfield started producing firearms for the Army in 1778, and it has been manufacturing ordnance ever since. Springfield Armory was already ancient when Longfellow wrote a poem about it. Our production of Garands at Springfield has soared 600 per cent, with 3 shifts of skilled workers operating 6 days a week and 24 hours a day. The citizen soldiers of America can take pride in that achievement. The Garand is a fine rifle and its constantly increasing production is a tribute not only to the men and the machines that make it but to the men who use it as well.

"Springfield is turning out nearly 600 Garands a day. Our goal is 405,000 at Springfield, plus 65,000 which the Winchester Company is producing for us. That total of less than half a million, someone may say, will not give a Garand rifle to every soldier. We don't intend to give a Garand to every soldier any more than we intend to give an airplane to every man in the Air Corps or a fieldpiece to every artilleryman. The Garand rifle is exclusively an infantry weapon, but not for every infantryman. Machine-gunners and soldiers who will man special weapons will, of course, be equipped with their own specialties. They will depend on the revolver for personal protection.

"We would have been derelict in our duty had we forgotten the one great lesson that the World War taught us. This lesson taught us the necessity of industrial-mobilization planning. Together the Army, the Navy, and American industry have worked on it year in and year out. We have kept our decentralized system of operation in existence throughout the years, and with the loyal help of industrial leaders we have sustained contacts with industry and the engineering professions.

"No better proof of this exists than the incident of last July when the present mammoth Ordnance program was presented to the Congress. Immediately it became known that an armament program totaling two billions of dollars was to be authorized, I called to Washington the civilian chiefs of our thirteen Ordnance districts and placed the problems involved squarely before them. Because we had planned well, these gentlemen were in a position to activate their organizations locally so that our basic ordnance principle of decentralized operation could be put into effect at once. When, nearly two months later, appropriations became available, the nation-wide Ordnance organization was ready to go into action. No time was lost once the starting whistle was blown.

"The chiefs and assistant chiefs of the thirteen Ordnance districts are prominent industrialists. Here in Birmingham we have Col. Theodore Swann as district chief and Mr. George M. Morrow, Jr., and Capt. Allen Rushton as assistant district chiefs. I wish to take this opportunity to thank them publicly for their unselfish and untiring efforts in planning during past years for ordnance production in an emergency and for the execution of those plans now that we are in an emergency. I wish also to express my appreciation of the great help and assistance rendered by their able Reserve officers and civilian assistants and particularly to the members of the Birmingham Post, Army Ordnance Association, who are participating in this meeting tonight.

"It is easy to speak of a billion dollars, but it is something else to turn that billion into military equipment—into food and clothing and shelter for the new Army, and into weapons to arm it. For that is the be-all and end-all, the alpha and omega, of this defense program—to raise and train an army and to put it in readiness to meet all comers. If we do that, and do it the right way, and do it as speedily as we can, we are likely to discourage any would-be aggressors. Security is our watchword, the goal of all our effort. In the words of the Under Secretary of War, Robert P. Patterson, whose office exercises full supervision over this vast military procurement program and whose

place I am honored to fill here tonight: 'Our single aim is to make America safe for Americans, and tough for anybody else.' To that we can all say: 'Amen!' The safer America becomes for Americans, the better. The tougher America becomes for any one or any group opposed to the American way, better still. Your job and mine—the job of all of us—is our national defense, for a safe America, today, tomorrow, always!"

WASHINGTON POST

REGULAR meetings of the Washington Post, Army Ordnance Association, continue to be held monthly on the second Tuesday. Due to the constantly increasing attendance, Post officials have found it necessary to transfer the meetings to the Raleigh Hotel. Luncheon is served promptly at 12:30 and is followed by a 20-minute talk. The average monthly attendance is 175 members and guests.

At the January meeting, Brig. Gen. James K. Crain, Chief of Field Service of the Ordnance Department, was the principal speaker. General Crain described the Ordnance service in our new Army organization. His address is published as an article in this issue on page 464.

Col. George F. Brady, Ord. Res., National Defense Advisory Commission, was the speaker at the February meeting. His topic was "Price Stabilization." The speaker at the March meeting, to be held Tuesday, March 11th, will be Brig. Gen. R. L. Maxwell, Administrator of Export Control. Col. F. H. Miles, Jr., president of the Post, recently appointed two committees to serve in connection with the Post's program of monthly meetings. The Committee on Program includes Lieut. Col. I. A. Luke, Maj. E. N. Clark, Maj. J. B. Medaris, A. H. Moran, and O. T. Wingo. The Committee on Reception will consist of: Lieut. Col. H. W. Churchill, Col. W. D. Lockwood, Col. J. G. Cowling, Maj. J. C. Raaen, and Capt. B. S. Mesick. Colonel Miles also announced the appointment of Maj. Ralph I. Graves as treasurer of the Post to succeed Lieut. Col. Colin E. McRae, who resigned from the office at the time of his retirement from active Government service.

NEW YORK POST

THE first of a series of meetings of the New York Post, Army Ordnance Association, was held on the evening of February 24, 1941, in the auditorium of the Engineering Society's building in that city. It was in the form of a question-and-answer forum on ordnance procurement. A board of experts, including officers of the Ordnance Department, U. S. Army, a representative of the National Defense Advisory Commission, and industrial executives working on Ordnance contracts, were present to answer questions and to give helpful advice to those directly or indirectly engaged or interested in manufacturing Ordnance matériel.

The forum, the first of its kind ever conducted, was free and open to all members of the Army Ordnance Association and their guests, and engineers and executives of industry. Members and guests were invited to submit questions in advance, as the major portion of the meeting was devoted to answering these advance queries. The committee of arrangements comprised Brig. Gen. Samuel McRoberts, president of the Post; Col. J. K. Clement, Col. James E. McNary, Col. Thomas F. Brown, Col. Crosby Field, Lieut. Col. W. John Hoffman, Maj. C. Stewart Comeaux, R. E. Gillmor, Thomas E. Murray, W. C. Dickerman, Charles J. Hardy, H. M. Tillinghast, Hartley Barclay, and James R. White.

CINCINNATI POST

THE annual election of officers, Cincinnati Post, Army Ordnance Association, brings to the presidency of that organization one of the leading figures in the Ordnance cause in the Middle West since the World War, August H. Tuechter. Mr. Tuechter has been an officer of the Post for many years. Col. A. H. Pugh was elected to the vice-presidency, and Lieut. Col. Fred A. McMahon was reëlected to the secretaryship as was Lieut. J. D. Wyatt, treasurer.

J. B. Doan, formerly president of the Post, was elected to the directorate of the national Association representing the Post. Directors elected for the years 1941 and 1942 were: E. A. Muller, chief of the Cincinnati Ordnance District; F. L. Burke, Louis Schwitzer, and C. W. Wheland. The following directors who were elected in December 1939 remain in office through the year 1941: F. W. Geier, E. D. Smith, A. F. Hubbard, and H. C. Knowles. The newly elected officers and directors were inaugurated at a meeting held at the Cincinnati Club, January 13, 1941.

NEW MEMBERS

DURING the period December 1, 1940, to January 31, 1941, inclusive, the following applicants were admitted to membership in the Army Ordnance Association: Carl A. Ackerman, Elmira, N. Y.; E. Russell Ackerson, Braintree, Mass.; Benjamin S. Albertson, Jr., Lewes, Del.; A. D. Alexander, Cleveland, Ohio; N. T. Alexander, Cleveland, Ohio; Joseph L. Aman, Fort Sam Houston, Tex.; Bruce H. Anderson, Boston, Mass.; Armand J. André, Chicago, Ill.; George K. Atkinson, Anderson, Ind.; Ralph G. Atkinson, Fort Benning, Ga.; Rudolph A. Axelson, Ann Arbor, Mich.; Nathaniel M. Aycock, Yonkers, N. Y.

Robert G. Baker, Fort Knox, Ky.; James F. Baldwin, Dover, N. J.; A. J. Ball, Youngstown, Ohio; A. E. Barker, Orange, N. J.; George E. Barnes, Floral Park, L. I., N. Y.; John J. Barnhardt, Jr., Ithaca, N. Y.; Gerald R. Barrett, New York, N. Y.; A. W. Barry, Philadelphia, Pa.; John J. Barry, Evanston, Ill.; Heston Bates, Fort Buchanan, P. R.; Frederick G. Bauer, New York, N. Y.; John G. Bauriedel, Grants Pass, Oreg.; C. H. Beck, Wilmerding, Pa.; William L. Bell, Jr., West Point, N. Y.; Walter Bender, Cleveland, Ohio; William C. Bertsche, Cincinnati, Ohio; Rowland J. Black, Buffalo, N. Y.; George W. Blair, Mishawaka, Ind.; Nicholas J. Blake, Detroit, Mich.; Howard B. Blanchard, Washington, D. C.; R. K. Blanchard, New York, N. Y.; William C. Blanchard, Traverse City, Mich.; James E. Blue, Detroit, Mich.; Kenneth Boll, Ann Arbor, Mich.; T. S. Bonnema, Cleveland, Ohio; Gerard H. Boss, Philadelphia, Pa.; Charles R. Botsford, Fort Benning, Ga.; Gilbert W. Boush, Wilmington, Del.; Harvey Bower, MacDill Field, Fla.; Edward B. Bowker, Ocean City, N. J.; Donald A. Boyd, Detroit, Mich.; Robert P. Boyer, Boston, Mass.; B. M. Boyle, York, Pa.; James W. Brackett, Fort Lewis, Wash.; Newell C. Bradley, Philadelphia, Pa.; Frank Brady, Fort Bragg, N. C.; R. M. Brady, New York, N. Y.; Charles G. Bragg, Palo Alto, Calif.; George C. Brainard, Youngstown, Ohio; R. F. Brandt, Los Angeles, Calif.; William J. Brennan, Aberdeen Proving Ground, Md.; John H. Briggs, Cleveland, Ohio; William H. Brinkley, Charlotte, N. C.; Keith R. Bronson, Ann Arbor, Mich.; G. Clymer Brooke, Birdsboro, Pa.; Ben C. Brosheer, New York, N. Y.; James R. Brown, Springfield, Mass.; Kenneth C. Brown, Washington, D. C.; Lawrence Brown, Washington, D. C.; R. W. Brown, Akron, Ohio; Wallace K. Brown, Montclair, N. J.; Brinton Buckwalter, New York, N. Y.; A. A. Bull, Ann Arbor, Mich.; C. B. Bunch, Pasadena, Calif.; Clarence E. Buote, Pawtucket, R. I.; Lorenzo D. Burnell, Grosse Pointe, Mich.; C. L. Burnham, Winnetka, Ill.; Joseph A. Butler, Fort McKinley, Maine; Newton S. Butz, Fairfax, Va.; James W. Bv[illegible]es, Houston, Tex.

DeRosey C. Cabell, Aberdeen Proving Ground, Md.; William Cadogan, Arlington, Mass.; George P. E. Caesar, Jr., Milwaukee, Wis.; Peter S. Carlson, Ayer, Mass.; Arthur A. Carr, St. George, S. I., N. Y.; W. J. Carry, Valley Stream, N. Y.; Albert C. Carter, Opelika, Ala.; John J. Casey, Ann Arbor, Mich.; E. A. Cassidy, Washington, D. C.; Pierre Champion, Cleveland, Ohio; Vernon B. Chase, Cincinnati, Ohio; Nathan B.

Chenault, Jr., Metuchen, N. J.; Forton A. Christoffer, Cincinnati, Ohio; Chester W. Clark, Los Angeles, Calif.; Daniel Keith Clark, Ann Arbor, Mich.; Richard E. Clark, New Britain, Conn.; C. V. Clarke, Bethlehem, Pa.; W. H. Cobb, New York, N. Y.; Robert Cohen, Lincoln, Nebr.; Lewis S. Colby, Columbus, Ohio; Bradford C. Colcord, McKeesport, Pa.; Irving H. Comroe, Watertown, Mass.; John Connelly, New York, N. Y.; W. W. Cowgill, New York, N. Y.; Osborn S. Cox, Lapeer, Mich.; Frederick G. Crabb, Fort Knox, Ky.; Arthur C. Cragg, Jr., Chicago, Ill.; Harold W. Cramer, Washington, D. C.; J. D. Cruce, Fort Bragg, N. C.; Arthur J. Cummings, Bridgeport, Conn.

O. L. Dally, Akron, Ohio; Marshall E. Darby, Washington, D. C.; James E. Davoli, Ann Arbor, Mich.; Parker S. Day, Fort Oglethorpe, Ga.; Gillard D. Dearlove, Chicago, Ill.; Lewis A. DeBlois, New York, N. Y.; Arthur K. Deming, Ayer, Mass.; Alexis M. Derkatch, Los Angeles, Calif.; Augustus R. DeVos, Hoboken, N. J.; Donald Diem, Ann Arbor, Mich.; Samuel W. Doan, Montgomery County, Pa.; Elmer C. Dodt, Detroit, Mich.; Chase Donaldson, Washington, D. C.; R. H. Donaldson, St. Paul, Minn.; William J. Durrenberger, Joliet, Ill.

Edward B. Ekdahl, Irvington, N. J.; Calvern L. Elgert, Baltimore, Md.; Gilbert L. Elliott, Springfield, Ohio; John C. Enblom, St. Paul, Minn.; George G. Ensign, Elgin, Ill.; Roy E. Erdman, Brooklyn, N. Y.; John Paul Evans, New York, N. Y.

George R. Farrell, Youngstown, Ohio; J. Faucher, New York, N. Y.; H. A. Feldbush, Holyoke, Mass.; James D. Filleul, Watertown, Mass.; Sol P. Fink, Scarsdale, N. Y.; George A. Fish, Norwalk, Conn.; E. H. Fisher, York, Pa.; William J. Fisher, York, Pa.; W. E. Fletcher, Philadelphia, Pa.; Russell T. Flora, Troy, Ohio; Daniel F. Flowers, Cambridge, Mass.; John F. Flowers, Fort Oglethorpe, Ga.; Michael H. Flynn, Hartford, Conn.; James B. Forbes, Mount Vernon, N. Y.; Raymond O. Ford, Ithaca, N. Y.; R. H. Fornwalt, McArthur, Ohio; Woodrow G. Frailing, Ann Arbor, Mich.; R. T. Freiday, Syracuse, N. Y.; G. W. Frick, Pittsburgh, Pa.; John H. Frye, Washington, D. C.

Harald H. Gade, Norristown, Pa.; E. B. Gallaher, Norwalk, Conn.; Robert M. Gates, New York, N. Y.; Raymond H. Gauthier, Ann Arbor, Mich.; Richard N. Gaylord, Westfield, Mass.; J. N. Gehred, Cincinnati, Ohio; W. R. Gerhardt, Fort Monroe, Va.; Harold A. Gerrish, Aberdeen Proving Ground, Md.; Sidney L. Gibson, Springfield, Mass.; Jack Gilder, Los Angeles, Calif.; F. D. Gillen, Akron, Ohio; A. R. Glancy, Detroit, Mich.; Richard Goldsmith, New York, N. Y.; F. Gray Goudy, Baltimore, Md.; A. S. Gould, Cleveland, Ohio; G. T. Gourley, Youngstown, Ohio; I. Grageroff, Clifton Forge, Va.; Andrew J. Graham, Jackson Heights, N. Y.; Edward J. Graham, Chicago, Ill.; H. E. Gray, New York, N. Y.; Raymond J. Green, Ann Arbor, Mich.; D. J. Gregory, York, Pa.; Eli Edward Gregory, New York, N. Y.; George F. Griffith, Radford, Va.; Walter F. Grote, Bellevue, Ky.; S. A. Guiberson, Jr., Dallas, Tex.

Frederick T. Haddock, Jr., Boston, Mass.; Charles Newton Hagar, Jr., Ann Arbor, Mich.; George L. Halamka, Metuchen, N. J.; F. D. Haley, Cleveland, Ohio; Joseph M. Hallissy, Jr., Ann Arbor, Mich.; F. W. Hankins, Philadelphia, Pa.; John J. Hanrahan, Brooklyn, N. Y.; Thorwald E. Hansen, Richmond, Va.; Felix Hargrett, New York, N. Y.; J. L. Haugh, Omaha, Nebr.; W. I. Heasley, Los Angeles, Calif.; G. A. Heckert, York, Pa.; Elbert A. Hedge, San Francisco, Calif.; Arne Hedstrom, Chicago, Ill.; Carl C. Hehl, Cincinnati, Ohio; Mark W. Helm, Euclid, Ohio; Stanley E. Hess, Cincinnati, Ohio; Thomas Hewes, Washington, D. C.; Walter R. Hibbard, Waterbury, Conn.; Eugene P. Higbee, University Heights, Ohio; John W. Higgins, Warren, R. I.; Ernest J. Hill, Cincinnati, Ohio; Edward A. Hobart, Troy, Ohio; Frederick S. Hodgman, Glen Rock, N. J.; Joseph C. Hoffman, Newport, Ky.; Melvin P. Holderness, East Detroit, Mich.; S. E. Horton, Walpole, Mass.; MacLean Houston, Warren, Pa.; John R. Howard, III, Birmingham, Mich.; Edwin Huge, Cleveland, Ohio; Richard Hugger, Norwalk, Conn.; Daniel G. Hulett, Cambridge, Mass.; Orene Hurlbut, Hickam Field, T. H.; Richard M. Hurst, Fort Benjamin Harrison, Ind.; Chester M. Hyde, Kirkwood, Mo.; Richard R. Hydeman, Boston, Mass.

Harry S. Imming, Jr., Ann Arbor, Mich.; Peter T. Ingram, New York, N. Y.; Robert Iredell, Akron, Ohio; William A. Isenberg, Charlotte, N. C.; G. S. Iskyan, Jackson Heights, N. Y.

E. T. Jackman, Evanston, Ill.; G. A. Jacobs, Detroit, Mich.; H. P. Jaeger, Cleveland, Ohio; B. Japikse, Birdsboro, Pa.; Harry Jarvis, Aspinwall, Pa.; Francis G. Jenkins, Watertown, Mass.; Harvey S. Johnson, Cincinnati, Ohio; Merrill N. Johnson, Ann Arbor, Mich.; H. Halsey Jones, Boston, Mass.; R. E. Jones, Cleveland, Ohio.

William F. Kaiser, Flint, Mich.; Herbert S. Karch, Cuyahoga Falls, Ohio; Charles Kaye, Cincinnati, Ohio; R. H. Kellogg, Ivorydale, Ohio; Charles P. Kelly, New Rochelle, N. Y.; G. T. Kendrick, Shaker Heights, Ohio; K. W. Kennedy, Ogden, Utah; Verne C. Kennedy, Jr., Ann Arbor, Mich.; E. H. Kibler, Jr., Aberdeen Proving Ground, Md.; Harvey Kingery, Bogata, Ill.; C. B. Kinney, Philadelphia, Pa.; B. A. Kline, Birdsboro, Pa.; Marlowe H. Kluter, Richmond, Ind.; Douglas G. Knight, Ann Arbor, Mich.; A. J. Kohn, Cincinnati, Ohio; J. P. Kottcamp, Jr., Aberdeen, Md.; A. J. Kramer, Chicago, Ill.; Walter D. Kramer, Columbus, Ohio; Frederick C. Kuhnle, Grand Haven, Mich.; Ferdinand J. Kutikel, Baltimore, Md.; Henrik Kylin, East Cleveland, Ohio; Oskar Kylin, Cleveland Heights, Ohio.

John Marvin Lacy, Ann Arbor, Mich.; W. E. Laidlaw, Washington, D. C.; Morgan D. Lalor, Richmond, Va.; Louis Henry Lanctot, New York, N. Y.; T. B. Langdon, La Grange, Ill.; H. P. Laussucq, Birdsboro, Pa.; Leroy C. Leasure, Silver Spring, Md.; E. V. Lee, Washington, D. C.; R. W. Leedom, Hollywood, Calif.; William P. Lentz, Baltimore, Md.; Carl K. Lenz, New York, N. Y.; Frank L. Leonard, Cincinnati, Ohio; Simpson C. Leonard, Detroit, Mich.; Edward G. Le Stourgeon, Washington, D. C.; Ross C. Little, Zanesville, Ohio; Thomas T. Logie, Bridgeport, Conn.; Frank J. Long, Cleveland, Ohio; John C. Lougheed, Wheeling, W. Va.; Wilfred W. Lowther, St. Paul, Minn.

Willis H. Machin, Waterbury, Conn.; Edward H. MacInnis, Philadelphia, Pa.; Nicholas C. Mandragos, Washington, D. C.; H. S. Marlor, Nougatuck, Conn.; Edward J. Martin, Cincinnati, Ohio; L. D. Martin, Cleveland, Ohio; James F. Matousek, Berwyn, Ill.; Joseph J. Matt, Jr., Ann Arbor, Mich.; H. A. Maurer, Cleveland, Ohio; G. E. McAllister, Cleveland, Ohio; George R. McCann, Brooklyn, N. Y.; L. B. McCarthy, Youngstown, Ohio; J. E. McCauley, Birdsboro, Pa.; Walter B. McClelland, Cleveland Heights, Ohio; D. W. McClure, Youngstown, Ohio; Willis O. McDaniel, Augusta, Ga.; Fred McFawn, Detroit, Mich.; F. M. McGee, Chicago, Ill.; J. S. McKee, McArthur, Ohio; Eugene A. McLaughlin, Cleveland, Ohio; Melvin W. McOmber, Wethersfield, Conn.; Joseph A. Meaney, Philadelphia, Pa.; Carl R. Meckstroth, East Cleveland, Ohio; Orval H. Menke, Troy, Ohio; C. R. Metcalf, Cleveland, Ohio; Emmery Mihaly, Benicia, Calif.; Stephen J. Millet, San Antonio, Tex.; David B. Mitchell, Cambridge, Mass.; John E. Mitchell, Jr., Albany, N. Y.; Joseph C. Montgomery, Hamden, Conn.; H. I. Moore, West Hartford, Conn.; V. H. Moorehouse, Cleveland, Ohio; William C. Morgan, Detroit, Mich.; E. Morgana, New York, N. Y.; Lowell Raymond Moss, Jr., Ann Arbor, Mich.; Arthur W. Mulborn, Camp Shelby, Miss.; Charles F. Muller, Cincinnati, Ohio; J. G. Murray, Cleveland, Ohio; Wilmer L. Myers, Fort Myer, Va.

James P. Neal, III, Fort Bragg, N. C.; Donald M. Nelson, Washington, D. C.; L. S. Newman, Cleveland, Ohio; Stanley H. Newman, Newark, N. J.; Richard S. Neymark, Ann Arbor, Mich.; H. L. Nicholson, Wilmerding, Pa.

W. M. O'Brien, Chicago, Ill.; Lockwood Oliver, Bay Village, Ohio; H. C. Olson, Camp Murray, Wn.; Tom O'Neil, Washington, D. C.; Charles D. Y. Ostrom, Jr., Berkeley, Calif.

J. Russell Palmer, Cleveland, Ohio; R. S. Papworth, Cleve-

land, Ohio; Francis W. Parker, III, Highland Park, Ill.; C. Clifford Parrish, Los Angeles, Calif.; George M. Paulson, New York, N. Y.; Francis S. Payne, Staten Island, N. Y.; James H. Peacock, Cincinnati, Ohio; Carl L. Peterson, Ann Arbor, Mich.; E. Peterson, Birdsboro, Pa.; George E. Philipsen, Aberdeen Proving Ground, Md.; Frank Willis Pierce, New York, N. Y.; Kenneth M. Pinkerton, Ingomar, Pa.; Thomas Plassmann, St. Bonaventure, N. Y.; M. Post, Birdsboro, Pa.; E. A. Purnell, Youngstown, Ohio; George P. Quinn, Chicago, Ill.; Roman M. Quintenz, Milwaukee, Wis.

Fred A. Radtke, River Forest, Ill.; Earle J. Raut, Ludlow, Ky.; William P. Rawles, Washington, D. C.; Elroy Reed, Elgin, Ill.; Clifford H. Reif, Jr., Cincinnati, Ohio; James J. Reilly, Atlanta, Ga.; Spencer Reitz, Ann Arbor, Mich.; R. F. Rentschler, Birdsboro, Pa.; Oliver A. Reynolds, Cleveland, Ohio; Gordon P. Rief, Cincinnati, Ohio; J. C. Rill, W. Philadelphia, Pa.; H. Rindal, Washington, D. C.; Stephen F. Roach, Jersey City, N. J.; H. E. Robb, Cleveland, Ohio; Elmer Roberts, New York, N. Y.; John A. Robertshaw, Youngwood, Pa.; J. J. Rodgers, Chicago, Ill.; W. Kemp Rogers, Jr., Ann Arbor, Mich.; Fred Rowits, Youngstown, Ohio; Philip A. Rush, Charlestown, Ind.; R. W. Russell, Huntington, L. I., N. Y.

Charles H. Salladé, New York, N. Y.; I. J. Samuelson, Cleveland, Ohio; D. M. Sarkisian, Forest Hills, L. I., N. Y.; Arthur J. Scaife, Drexel Hill, Pa.; Ernest F. Scherer, Ann Arbor, Mich.; George L. Schiel, Philadelphia, Pa.; Frank Wm. Schreiner, Cleveland, Ohio; Raymond I. Schnittke, West Point, N. Y.; G. Schulte, Manhasset, L. I., N. Y.; C. G. Schultze, Charlotte, N. C.; John W. Scott, Fort Francis E. Warren, Wyo.; Robert C. Seamons, South Gate, Calif.; L. B. Seitz, York, Pa.; Vaden C. Shadden, Chattanooga, Tenn.; Daniel J. Shaw, Washington, D. C.; Emmet Sheahan, Detroit, Mich.; Leo J. Sheridan, Ravinia, Ill.; Lawrence A. Shipman, Ann Arbor, Mich.; R. J. Short, Ivorydale, Ohio; Otto A. Shults, Rochester, N. Y.; Lee Sieber, Cincinnati, Ohio; Oliver Sigurdson, Los Angeles, Calif.; G. Richard Slonneger, Washington, D. C.; Forrest W. Smith, Cincinnati, Ohio; H. E. Smith, New York, N. Y.; Nelson H. Smith, Fayetteville, N. C.; W. G. Smith, Birdsboro, Pa.; I. I. Solzman, Omaha, Nebr.; Park T. Sowden, Philadelphia, Pa.; Richard M. Spengler, Philadelphia, Pa.; T. R. Stansfield, York, Pa.; Albert M. Stedfast, Wellesley Hills, Mass.; George Stehle, Erie, Pa.; Duane E. Steinle, Detroit, Mich.; Russell Stevenson, Detroit, Mich.; Shaler Stidham, Washington, D. C.; A. K. Stiles, Rock Island, Ill.; Thomas C. Stirling, Detroit, Mich.; A. W. Stoddard, McChord Field, Wash.; Irving K. Stone, Battle Creek, Mich.; Richard P. Stout, Boston, Mass.; George H. Straub, Brooklyn, N. Y.; Robert J. Sullivan, Reading, Pa.; Walter C. Summer, Fort Benning, Ga.; R. J. Swing, Philadelphia, Pa.; Ross W. Swogger, Cleveland, Ohio.

Charles E. Tackels, Detroit, Mich.; John L. Tangeman, Arlington, Va.; Warren M. Taylor, Cincinnati, Ohio; Howard Chandler Thayer, Jersey City, N. J.; Charles D. Thibault, Arlington, Va.; Dorsey O. Thomas, Washington, D. C.; Walter M. Thomas, Brooklyn, N. Y.; J. S. Throne, York, Pa.; Arnold Tietig, III, Cincinnati, Ohio; L. D. Tompkins, New York, N. Y.; Richard F. Towner, Ann Arbor, Mich.; W. W. Tranter, York, Pa.; Charles Treichal, Cleveland, Ohio; William F. Turschmid, Glendale, L. I., N. Y.; James K. Tyson, Boston, Mass.

Sharon S. Ulrey, Ann Arbor, Mich.; George Uzmann, Rockville Center, L. I., N. Y.; Harold S. Van Buren, Glendale, Ohio; Jacque Van Gieson, Ann Arbor, Mich.; Harry H. Van Kirk, Jr., Troy, Ohio; W. G. Vernon, York, Pa.; Robert Voss, Ann Arbor, Mich.

F. G. Wahl, Cleveland, Ohio; C. E. Wallace, Coffeyville, Kans.; Dudley W. Watkins, Jr., Ann Arbor, Mich.; Thomas J. Watson, New York, N. Y.; Roy J. Weaver, Denver, Colo.; James E. Webb, New York, N. Y.; Roland E. Webster, Joplin, Mo.; C. R. Wefler, Cleveland, Ohio; Louis A. Wehle, Rochester, N. Y.; Alfred F. Weimann, Cranford, N. J.; Wesley M. Welborne, Cincinnati, Ohio; Arthur B. Wendt, Ann Arbor, Mich.; J. C. Weston, Detroit, Mich.; Earl H. Wheeler, New Britain, Conn.; Gaylord C. Whitaker, Rochester, N. Y.; A. M. Wibel, Birmingham, Mich.; Harvey Ladow Williams, Greenwich, Conn.; Shelby Williams, Cleveland, Ohio; L. Waring Wilson, Long Island City, N. Y.; William M. Wood, Ann Arbor, Mich.; Morton P. Woodward, Glendale, Ohio; John E. Woolley, New York, N. Y.; Harry T. Woolson, Detroit, Mich.; George F. Wright, Toronto, Ontario, Canada; Haviland Wright, Chestnut Hill, Pa.; W. A. Wright, Wabash, Ind.; W. R. Yaw, Detroit, Mich.; A. R. Zapp, South Hills, Pittsburgh, Pa.

NECROLOGY

CHARLES RAYMOND MESSINGER, assistant chief of the Chicago Ordnance District, died at his home in Milwaukee, February 5, 1941. For the past three years he had served as assistant to Fred A. Preston, chief of the district. He had taken a helpful part in the activities of the district under its present emergency program and was especially energetic in the affairs of the Milwaukee Post, Army Ordnance Association. His loss to industry—he was president of the Chain Belt Company and of the Oliver Farm Equipment Company—is no less great than it is to the Ordnance ranks among whom his counsel and guidance were of great value.

Mr. Messinger was born at New Haven, Conn., October 27, 1883, and was graduated from the Sheffield Scientific School of Yale University in 1906. For nearly twenty years he was vice-president and general manager of the Sivyer Steel Casting Company and for the past ten years he had been chairman of the board. During the World War he was vice-president and general manager of the Chain Belt Company and later was promoted to the presidency of that organization. He was a director of many industrial organizations in Chicago and Milwaukee and maintained offices in both cities, being closely identified with industry throughout the area. In Milwaukee, where he maintained his home, he was a leader in civic and municipal enterprises. He served as chairman of the Milwaukee County Community Fund, as trustee of the Milwaukee Art Institute and director of the Milwaukee County Day School.

Mr. Messinger rendered particularly meritorious service to the Ordnance Department during the World War when he served as a special consultant to the Chicago Ordnance District on the production of steel castings. He was also chairman of the committee on standardization of chain. His services in the field of steel castings—a difficult and urgent war-time requirement—were of material value in hastening the Ordnance production program of 1917-1918. In those days he was also vice-chairman of the Red Cross for Milwaukee County, in addition to his many other interests.

To the Ordnance forces of the Chicago area, ARMY ORDNANCE extends its condolences in the loss of a leader of industrial preparedness. Mr. Messinger represented in full measure a type of American industrial leadership upon which the success of military preparedness in normal as well as in emergency times must depend. Always equal to his responsibilities in an area where the industrial strength is a major part of our Ordnance production capacity, his leadership in the emergency of 1917, his interest during the intervening years and his counsel in the emergency of 1940-1941 will testify to his worth. The Ordnance Department of the Army, now in the midst of a large production program, can ill afford the loss it has sustained.

NOTICE has been received of the death of the following members of the Association: John Calahan, Jersey City, N. J.; Hal F. Coombs, Bloomfield, N. J.; William S. McAbee, Wilkinsburg, Pa.; Merle E. McCoy, Coraopolis, Pa.; Charles F. Morley, Rochester, N. Y.; Charles A. Rowan, Wilmerding, Pa.; Samuel Strumer, New York, N. Y.; Robert W. Withington, Philadelphia, Pa.

Ordnance in Review

THE SEDGLEY SUBMACHINE GUN

BY LIEUT. COL. CALVIN GODDARD

IN THE January-February 1941 issue of ARMY ORDNANCE, these columns were devoted to the discussion of a new submachine gun chambered for the .45 Colt automatic-pistol cartridge and manufactured by the Harrington & Richardson Arms Company, of Worcester, Mass. Statement was made to the effect that combatant nations today appear to be manifesting no little interest in this type of arm. Further evidence of that fact is adduced by the steps taken by two other producers of firearms

THE NEW SEDGLEY SUBMACHINE GUN

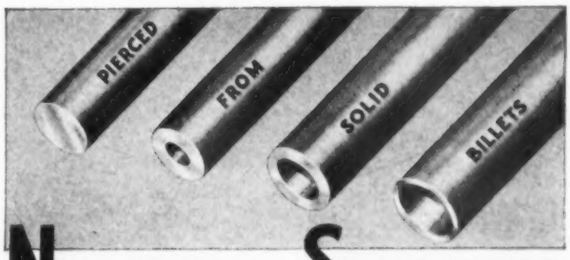
in the United States who have been bending their energies toward the development of additional pieces of somewhat similar characteristics.

The firms in question are Smith & Wesson, of Springfield, Mass., and R. F. Sedgley, of Philadelphia, Pa. Both of these have chosen a bore of 9 mm. for their weapons, but apart from likeness in caliber, they appear to possess few features in common.

The Sedgley weapon, illustrated herewith, is at a casual glance not unlike the comparable Harrington & Richardson product in general appearance, though one is immediately struck by the difference in the location of the magazine. This, in the Sedgley, is at the front end of the forestock, as against a position midway between front of trigger guard and tip of fore-end in the H&R. It is produced in barrel lengths of eight and eleven inches—the former for police use, the latter for the military. All features of construction are said to be extremely simple, there being but four moving parts, and the prospectus at hand indicates that assembly and disassembly may be carried out speedily and easily even by the novice. The perforated sleeve which surrounds the barrel for ventilation is reminiscent of that employed in the Bergmann (German) and Solothurn (Swiss) weapons, both of which are well known overseas, though not often met with in the United States.

Designed for semiautomatic, or fully automatic fire, the changeover is effected by the manual operation of a small lever. The magazine, of the detachable-box variety and conventional 20-round capacity, is symmetrically located in a vertical plane beneath the barrel, as against the horizontal position it occupies in the Bergmann where, projecting laterally from the left side of the frame, it is not only unsightly but tends to produce by its weight, especially when loaded, an anticlockwise cant in the piece. Its convenient forward location on the Sedgley permits ready use as a hand grip, under which circumstance it should contribute no little to the stability of the weapon during full-automatic fire.

Examination of the illustration suggests that in this piece, as in the Bergmann, Thompson, and others, the bolt is fully retracted at the instant when the trigger is pressed. If this assumption be correct, the bolt must, when so released, travel forward with ever-increasing velocity, stripping a cartridge from the



NATIONAL SEAMLESS

America's Preferred Pipe and Tubes

Pierced from solid steel!

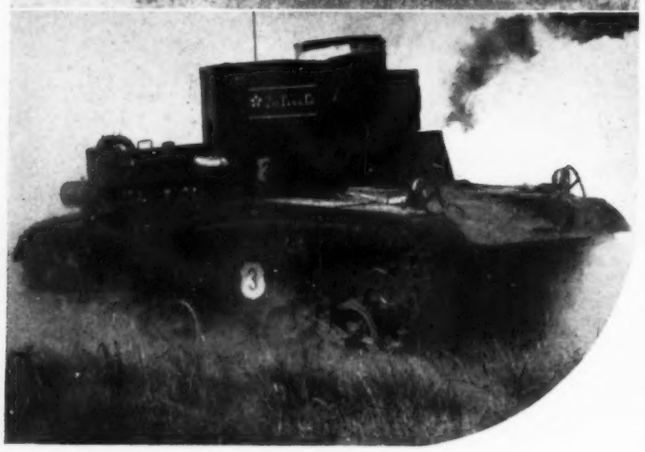
NATIONAL Seamless Pipe and Tubes are pierced from clean, flawless billets of highest quality steel. This material has no longitudinal weld, therefore no line of potential weakness. It is available in sizes ranging from 3/16-inch mechanical tubing to 28-inch O.D. pipe, and in wall thicknesses to meet practically any requirement. Various grades of steel, from plain carbon to the high-alloy grades, can be supplied.

The seamless process is particularly adapted to the production of heavy walled tubing, various types of cylinders, and tubular forgings in a wide range, especially where upsetting, swaging, spinning, or bending operations are to be performed and where a clean, smooth bore or surface finish is highly important. Either as NATIONAL Seamless Pipe or as Shelby Seamless Mechanical Tubing, the identifying emblem, "Walls Without Welds," means—America's Preferred Pipe and Tubes.

NATIONAL TUBE COMPANY
Pittsburgh, Pa.

UNITED STATES STEEL

READY
with SKF
ON MEDIUM TANKS



ON LIGHT TANKS

Light and medium tanks are rolling off production lines—ready for action and assured of many smoothly working parts by SKF Ball and Roller Bearings. SKF Industries, Inc., Philadelphia, Pa.

4761

SKF
BEARINGS

magazine in its passage, introducting this into the chamber, and reaching its fully closed (forward) position ere the firing pin can be actuated to discharge the weapon. As observed in the review of the H&R product, this type of action tends to set up considerable unpleasant vibration when the arm is being fired semiautomatically and can hardly contribute to accuracy under such circumstances. During fully automatic firing, however, other conditions not conducive to bullseyes are so noticeable in practically all similar weapons that this feature ceases to be worthy of serious consideration.

The action, like that of the Bergmann, is of the straight blowback type, the inertia of the moving parts evidently being great enough to permit the successful use of such a mechanism.

SINCE the announcement of the availability of the Sedgley arm comes so soon after that of the H&R, it may be of interest to contrast their specifications, together with such as are available in respect of the Bergmann, as follows:

Characteristic	*Sedgley*	*H & R*	*Bergmann*
Weight	7 lbs. (8-in. barrel) 7½ lbs. (11-in. barrel)	6½ lbs.	9.35 lbs.
Barrel length	8 in. and 11 in.	11 in.	7⅞ in.
Overall length	35 in. (approx.)	32½ in. (approx.)	32.28 in.
Magazine capacity	20 rounds	20 rounds	50 rounds
Cyclic rate of fire.	(?)	450-500	600
Action	Straight blowback	Delayed blowback	Straight blowback
Sighted to	300 yds.	300 yds.	1,000 meters
Safety	Blocks bolt handle (?)	Blocks sear (?)	Blocks bolt handle
Caliber	9 mm. (Luger)	.45 A.C.P.	9 mm. (Luger)
Bullet weight	124 gr.	230 gr.	124 gr.
Muzzle velocity	1,210 f.s.	860 f.s.	1,185 f.s.
Muzzle energy	403 ft. lbs.	378 ft. lbs.	386 ft. lbs.
Cooling device	Perforated sleeve	None	Perforated sleeve

While the calculated energy of the Luger missile exceeds that of the .45 automatic, experience has amply demonstrated that large sectional area combined with good sectional density endows a projectile, other things being equal, with greater "shock power" than is possessed by one of lesser area (caliber) even though the velocity and energy figures for the latter exceed those of the former. In an effort to establish a workable formula whereby the comparative shock powers of different handgun projectiles could be assigned relative values on an arbitrary scale, Col. Julian S. Hatcher, Ord. Dept., U. S. A., devised some years ago a table wherein he estimated the shock power of bullets of different diameters, traveling at varying velocities, by multiplying the energy of a given missile by its sectional area. His figures were based on velocities considerably less than those now imparted to the projectiles under consideration, but I have undertaken to correct these to compensate for the increases.

On such a basis, we find that the shock power, or shock factor, for the 230-grain, caliber .45 automatic-pistol bullet with a muzzle velocity of 860 feet per second, and a muzzle energy of 378 foot pounds, is 60, as against 40 for the 9-mm. Luger at 1,210 foot seconds and 403 foot pounds. And since, at 100 yards, the Luger loses (by Hatcher's tables) 20 per cent of its original velocity in contrast with a loss of but 11.7 per cent on the part of the .45, we may deduce that, if this relative proportion still roughly holds (and it is reasonable to assume that it does), the .45 will be traveling at 760 foot seconds when it passes the 100-yard mark, while the Luger will be down to 968 foot seconds. Thus their respective energies at this range become 294 and 257 foot pounds, and their relative shock powers, 46.7 and 25.4.

In the hands of the military, the submachine gun is employed only at close quarters, and in desperate situations—situations in which knockout blows must be dealt and dealt quickly. The .45 has demonstrated its ability to do this. Lesser calibers (witness U. S. Army experience in the Philippines) often fail. Let's not send a boy to do a man's job. However, the implication that submachine guns of reduced caliber possess poor military characteristics is not to be considered a criticism of the *design* embodied in any of the weapons just discussed, since it would appear that all these are, with or without slight modification, adaptable to such larger calibers as the .45 A.C.P.

Ordnance Reserve

NEW PHYSICAL EXAMINATION INSTRUCTIONS FOR RESERVE AND NATIONAL GUARD OFFICERS

ADDITIONAL instructions supplementing and, in some instances, superseding previous instructions governing the physical examination of Reserve officers and National Guard officers ordered to active duty for periods of more than thirty days, have been announced by the War Department.

According to the new instructions, only *one* examination is prescribed or authorized for each officer to determine his physical qualification for extended active duty. This examination, however, carries with it the right of appeal in certain cases. It may be given not more than sixty days prior to the effective date of each officer's active duty, or after he has reported for such active duty, subject to the following provisions:

1. Examinations *prior* to actual entry upon active duty will be made at the option and upon the request of the individual concerned, and without expense to the Federal Government for travel or pay. No funds are available for these purposes.

2. A National Guard officer *not* examined prior to induction, as authorized above, will be examined at the earliest practicable date following induction. If it is not practicable to give such an examination before he departs from his home station, the examination will be deferred until his arrival at his unit training center or other station where the necessary medical personnel and facilities are available and in any event within the first thirty days of active duty. In such cases, the commanding general of the corps area or department of origin will notify the Army commander concerned, who will arrange with the commanding general of the corps area or department of destination for the necessary examination.

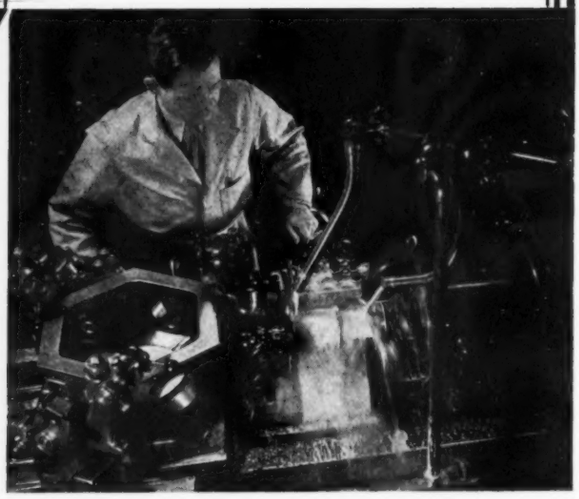
3. A Reserve officer not examined prior to entry upon active duty will be ordered to active duty without a prior physical examination. If he is to be permanently assigned to a station in his corps area or department of residence not more than 500 miles distant from his home, and if this station has the necessary medical personnel and equipment to make physical examinations of the type prescribed by Army Regulations, he will be ordered to proceed directly to his permanent station where the necessary physical examination will be given. If the officer's first permanent assignment is to be: (a) A station outside the corps area or department of his home; (b) A station more than 500 miles from his home, or (c) A station within the corps area or department of his home but one at which personnel and equipment required for physical examination are not available, he will be assigned to his permanent station but ordered to proceed on *temporary* duty to the nearest Army station where the physical examination prescribed by Army Regulations can be made. If found physically qualified, he will then proceed to his permanent station in compliance with original orders. In any event, the physical examination shall be completed within the first thirty days of active duty.

To be acceptable, examinations prescribed by Army Regulations, whether made prior to or after entry upon active duty, must be made at an Army medical installation where professional specialists and proper facilities are available.

The examinations prescribed by Army Regulations will be made by boards of three or more medical officers, at least one of whom shall be an officer of the Medical Corps of the Regular Army. If practicable, in the examination of National Guard officers at least one member of the board will be a medical officer of the National Guard of the United States, and if practicable, in the examination of Reserve officers at least one member of the board will be a Reserve medical officer.

SULPHUR

in Special Cutting Oils Speeds Production



Photograph courtesy Warner & Swasey Co.

Sulphurized cutting oils have been found to be markedly superior to other types for maching the tougher metals. Sulphur adds film strength to a lubricant and it is believed that its effectiveness in cutting oils lies in its ability to act as an anti-flux to prevent the chip from welding to the tool.

Non-tarnishing Sulphurized cutting oils are doing yeoman's service in helping to turn out machines and ordnance. Production is speeded up because there is better lubrication for removing the chip from the work, better cooling action to prolong keenness of tool edge, and increased tool life by protecting it against wear by chips as they slide by.

TEXAS GULF SULPHUR CO.
75 E. 45th Street New York City
Mines: Newgulf and Long Point, Texas

PHYSICAL standards for all active duty are those prescribed in AR 40-100, AR 40-105, and, in addition, for the Air Corps in AR 40-110, except as modified for certain officers of the National Guard who were commissioned or examined and found qualified for Federal recognition or appointment in the National Guard of the United States prior to July 2, 1940.

Examination to determine physical qualification for extended active duty will include an X-ray of the chest, a serological test for syphilis, and a urine examination, including the microscopical examination. An electrocardiogram will be made if the officer is fifty years of age or older, if the officer is forty-five years of age or older and is required by assignment or orders to participate regularly in airplane flights, or if, in the opinion of the medical examiner, such examination is indicated.

Corps-area and department commanders, except in cases expressly reserved by the War Department, are authorized to make final determination of the physical qualification of individual officers without reference to the War Department, except in cases involving physical fitness for flying. Action in the latter cases will be as prescribed in AR 40-110.

In addition, they are authorized to grant waivers for physical defects where the interest of the Government or of the military service is not compromised, provided the defects will not interfere with the satisfactory performance of duties appropriate to the grade of the individual concerned and are not likely to be aggravated as a result of active military service. In certain other cases, waivers will be granted only upon the written request of the affected individual, and, in such cases pertaining to National Guard officers, the recommendation of the division or separate unit commander concerned also will be necessary. Each request for the latter type of waiver must be accompanied by an affidavit from the individual concerned acknowledging that the physical defects on which waiver is requested existed prior to entry into active military service and that they were not the result of such service.

Only the War Department and corps-area and department commanders are authorized to adjudge an officer physically disqualified for extended active duty, and only these authorities may authorize his relief from extended active duty for physical disqualification. Similarly, only these authorities may adjudge an officer physically qualified for active duty.

National Guard officers found to be disqualified as a result of physical examination prior to induction and whose Federal recognition is not withdrawn by that date will be relieved from active duty on the effective date of such induction, on orders issued by the corps-area or department commander.

If found to be disqualified as a result of physical examination subsequent to induction, National Guard officers will be relieved from active duty upon determination of disqualification, on orders issued by the army, corps-area, or department commander. If found to be physically disqualified, National Guard officers thereupon become subject to withdrawal of Federal recognition and termination of commission in the National Guard of the United States. Such withdrawal and termination will be accomplished by the War Department.

Reserve officers found to be physically disqualified as a result of physical examination prior to the effective date of active duty will not be ordered to extended active duty. If found to be physically disqualified as a result of physical examination subsequent to the effective date of active duty, they will be returned to their homes and relieved from active duty.

An officer already on extended active duty who is reported as physically disqualified by the board which conducted the examination of the type specified by Army Regulations will be retained on active duty pending decision on appeal, if request for appeal is made, or on request for waivers, if any.

To handle appeals, each corps-area and department commander will convene as many medical appeal boards as he deems necessary. Such boards will consist of two or more medical officers of mature experience and judgment, other than those comprising the

examination boards convened according to Army Regulations to physically examine officers.

If the physical examination of the type prescribed in Army Regulations discloses disqualifying defects, the officer will be so informed by the corps-area or department commander in whose jurisdiction the National Guard or Reserve officer was examined. This notice will announce the specific defects which indicate that the officer is physically disqualified for active duty. He will be advised in the same communication of his right to appeal from the findings of the board which conducted the physical examination, provided, if the officer is not on extended active duty, that he is willing to defray from personal funds the cost of travel involved in appearing before the appeal board and his subsistence in a hospital, if hospitalization is involved in the appeal examination.

In considering appeals, a medical appeal board will limit its examination to the disqualifying defects reported by the examining board. Medical appeal boards are without authority to extend their examinations beyond these defects. Where practicable, applicants will be ordered before an appeal board at a hospital or dispensary other than the one in which they originally were examined.

The right of appeal is retroactive to include all National Guard and Reserve officers who have been found to be disqualified physically for extended active duty since September 6, 1940, provided, if the officer is now on an inactive status, that the reëxamination be made without expense to the Government for travel and pay and provided further that the individual concerned subsequently has not been discharged from the National Guard of the United States or the Officers' Reserve Corps, as the case may be.

Except as to flying officers and as to officers whose cases have been expressly reserved by the War Department, action of the corps-area or department commander on recommendations of medical appeal boards will be final.

A Reserve officer who receives a physical examination of the type prescribed by Army Regulations, prior to the effective date of his extended active duty and who reports for active duty within sixty days thereafter, will be given a physical examination, as required by Public Resolution No. 96, Seventy-sixth Congress, to determine defects arising from intervening illness or injury since the prior complete examination.

Each such examinee will exhibit to the medical examining board his copy of the report of prior examination, and also will furnish the board a certificate in duplicate that he has or has not suffered an illness or injury since the date of the prior examination. The certificate will indicate in detail the nature and extent of any intervening illness or injury.

When required, examinations to determine physical defects arising from intervening illness or injury will be made at the earliest practicable date after the officer concerned has arrived at his permanent station, and in any event within the first thirty days of active duty. Such examinations will be made by one or more medical officers of the Army of the United States.

AN officer, examined within sixty days prior to actual entry upon active duty, and found physically qualified for such duty, will not be relieved from or rejected for active duty because of anything found in the examination to determine intervening disease or injury, except as follows:

If, because of intervening illness or injury, the officer concerned is unable to report in person to the place designated in his active-duty or induction orders, he will be examined at the place where he is confined by illness or injury. Final disposition of the cases of such officers will be made by corps-area and department commanders after consideration of the report of the medical officer or medical board who conducted the examination. The same examination shall be made and the same action taken with respect to an officer, previously not examined, who, because of injury or illness, is unable to report to the station and at the

We salute the colors . . . which have played such an important part in the making of American History.

The colors of Moore Porcelain Enameled Cooking Utensils also play an important part . . . in American life . . . for *only* enameled cooking utensils can give you the color and charm so desirable in the modern decorative kitchen.

Moore Enameled Ware can give your wife the joy and satisfaction that comes from cooking in *good* porcelain enamel. Moore's enamel is glossy, hard and beautiful as pure china . . . impervious to food acids and stains . . . enamel so smooth it requires no effort to clean . . . good enamel is non-porous, therefore sanitary and healthful . . . eliminates every chance of tainted or discolored foods from previous cooking use.

THE MOORE ENAMELING AND MANUFACTURING COMPANY
WEST LAFAYETTE · OHIO

BUY THE BEST
Buy Moore Enameled Ware
LOOK FOR THE NAME MEMCO ON THE LABEL

Helping make Munition Parts FASTER and BETTER!

Stuart's Thred Kut

PAT'D U. S. PATENT OFFICE

HERE'S why! Top-speed production—finish surpassing inspection requirements—and economy are the important reasons principal manufacturing armories, arsenals and industrial plants of all sizes are today using Stuart's Thred-Kut in increasingly large quantities.

In the machining of tough, stringy alloy metals, Stuart's Thred-Kut is outstandingly superior when the job demands velvet finish at maximum speed. Prove it on your most difficult cutting conditions.

A trial drum will start you on the way to top production and insure the quality of finish required. STUART OIL Engineering Service is available to help you secure maximum cutting fluid efficiency. Phone or wire today!

You should have this Handbook!

Send for this valuable 48-page handbook. It's full of data and engineering information that will help you produce munitions faster and better.

Stuart Oil Products

For all cutting fluid problems

D. A. STUART OIL CO.
LIMITED

Chicago, U.S.A. • Est. 1865

Warehouses in All Principal Metal Working Centers

time indicated in the orders directing his extended active duty.

If the officer who has reported in person to the designated place for active duty is considered to have a disqualifying defect, he will be ordered to an Army general hospital and, if found thereafter by a disposition board to be physically disqualified for active duty, he will be relieved from active duty by the corps-area or department commander, or in appropriate cases he will, upon approval of the War Department, be brought before an Army retiring board in accordance with the provisions of the Act of April 3, 1939. If approved findings of the disposition board determine that the officer is physically qualified for active duty, he will be ordered to his organization for duty.

Reserve Officers Assigned as Instructors at Aberdeen Ordnance Replacement Center

THE War Department has announced that seventy Ordnance Reserve 1st and 2nd lieutenants will be ordered on extended active duty for one year to serve as junior officers and instructors at the Ordnance Replacement Center, Aberdeen Proving Ground, Md. A total of 133 officers will be on duty at the Aberdeen Ordnance Replacement Center, where thirteen weeks' instruction will be given to selected trainees, starting about March 15, 1941. The center will have a capacity of about 5,800 men.

Thirty-five of the seventy officers reported to the Ordnance Training Center at Aberdeen on February 1st, and the remainder on March 1, 1941. Each group will be given a 1-month's refresher course at the Ordnance School there before being assigned to the Ordnance Replacement Center.

The number of officers to be selected in each corps area and the effective dates of their active duty follow:

Corps Area	*February 1, 1941*	*March 1, 1941*
First	4	4
Second	8	8
Third	7	7
Fourth	1	1
Fifth	5	5
Sixth	5	5
Seventh	2	2
Eighth	1	1
Ninth	2	2

The nine corps-area commanders will select the officers. If it is found impracticable to provide sufficient Ordnance Reserve officers of these grades to fill the allotment, the War Department has authorized commanders to select lieutenants of the Infantry Reserve and Cavalry Reserve who have the engineering background required of members of the Ordnance Reserve and who are qualified to give the required basic military instruction.

Designation of Officers on Active Duty

IN furtherance of the "One Army" idea, all Army officers, including Reserve and National Guard officers on active duty, will hereafter wear the same insignia and be designated in official papers in the same manner. The move is one designed to eliminate distinctions between the several officer components.

The regulations prescribe that "Reserve officers and officers of the National Guard in Federal service will wear the same insignia as officers of the Regular Army." It is also provided that in official papers only the rank of the officer, whether temporary or permanent, and the branch, arm, or service to which he is assigned, will be designated.

All temporary Regular Army general officers are appointed and commissioned in the Army of the United States without designation of arm or service. The assignment of a temporary general officer will determine his designation and insignia. General officers of the Reserve components holding permanent or temporary commissions, will wear the insignia as prescribed for general officers of the Regular Army. H. E. A.

Professional Digest

The following items of current information and opinion aim to present a wide range of facts and discussion relating to recent developments of professional military interest. Quotation marks are frequently omitted but sources are indicated.

PRODUCTION OF THE ARMY'S NEW SEMIAUTOmatic rifle by the Winchester Repeating Arms Company, New Haven, Conn., was begun January 10, 1941. At ceremonies marking the event, Maj. Gen. C. M. Wesson, Chief of Ordnance of the Army, described the occasion as "an historic advance in our armament strength." With General Wesson for inspection of the Winchester plant were: Maj. Gen. George A. Lynch, Chief of Infantry; Maj. Gen. John K. Herr, Chief of Cavalry; Brig. Gen. C. T. Harris, Jr., Assistant to the Chief of Ordnance and chief of the Industrial Service, Ordnance Department; Brig. Gen. Gilbert H. Stewart, commanding officer, Springfield Armory, Springfield, Mass.; Lieut. Col. G. H. Drewry, chief of the small-arms and small-arms ammunition division, Manufacturing Service, Ordnance Department; and John C. Garand, production superintendent at Springfield and inventor of the rifle.

Col. Frederick H. Payne, chief of the Hartford Ordnance District, arranged the inspection and was in charge of general plans. He was assisted by Col. Robert Sears, executive officer of the district, and members of his staff.

Nearly 600 Garand rifles are being produced daily at the Springfield Armory. Under present plans, a total of 405,000 of these rifles will be produced at Springfield plus 65,000 which the Winchester Company is producing.

WITH THE APPROVAL OF THE SECRETARY OF THE Navy, Col. Frank Whitehead, U. S. Marine Corps, has been appointed commandant of the Army Industrial College in Washington. Effective February 1st, Colonel Whitehead succeeded Lieut. Col. John E. Lewis, U. S. Army, who has been ordered to Fort Knox, Ky., for duty with the Armored Corps. This is the first time an officer of the Marine Corps has been given this assignment.

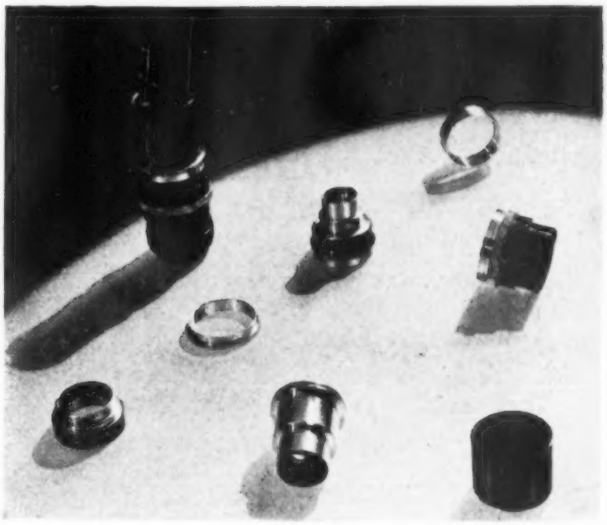
The new commandant was born in Camden, N. J., and enlisted in the Marine Corps on June 27, 1908. He served continuously as an enlisted man until August 16, 1917, when he was appointed a second lieutenant in the Marine Corps. He advanced through the various grades, becoming a colonel on July 8, 1940.

SPLIT SECONDS THAT ARE AGES TO A BULLET or a camera shutter are measured as easily as a wrist watch measures the time of day by a new device called a chronoscope, developed by the research division of the Remington Arms Company. The device, built into a small portable cabinet, splits the second 1,000 ways and will measure from 1 up to 200 of these milliseconds with less than 1 per cent error. It already has proved valuable for studying the effect of velocity and flight time of bullets on accuracy, range, trajectory, and hitting power, but its use is not confined to ballistics. Many important operations in science and industry are performed in much less time than is needed for the flick of an eyelash. Any of these can be clocked with the chronoscope providing only that an electrical impulse can be obtained at the beginning and end of the event.

COL. HOMER SAINT-GAUDENS, CORPS OF ENgineers, U. S. Army, who is on active duty as technical advisor on camouflage studies being conducted in the Office of the Chief of Engineers, says: "The technique of rear-area camouflage is wholly different from that of military front-line camouflage.

THE LENS MAKER ASKED FOR

"light weight, precision and fine finish"



Alcoa Aluminum screw machine stock meets all requirements. That's why Wollensak Optical Company turned to this stock for making this 3-inch Cine Telephoto lens.

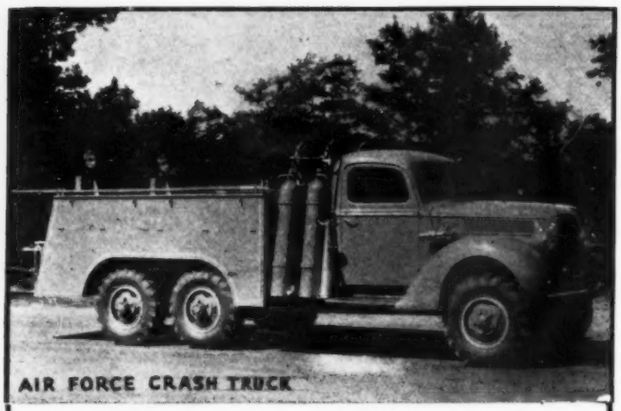
Aluminum reduces the over-all weight of the lens. This stock machines at high speeds and takes a fine finish. Dimensions are held to accurate limits and production schedules are maintained.

In comparing costs of screw machine products, remember that *with Aluminum* you get three times as many pieces per pound, compared with the heavy metals. Aluminum requires no expensive plated coatings, but it can be given a great variety of attractive, durable finishes.

ALUMINUM COMPANY OF AMERICA, 2137 Gulf Building, Pittsburgh, Pennsylvania.

IT'S NEVER COSTLY TO USE ALCOA ALUMINUM RIGHT

ALCOA ALUMINUM


AIR FORCE CRASH TRUCK

MILITARY VEHICLES
OF ALL TYPES

☆

COMBAT TANKS • ARMORED CARS
SCOUT CARS • RECONNAISSANCE CARS
OFFICERS CARS • AMBULANCES
MOBILE MACHINE SHOPS
ARTILLERY TRACTORS for Guns of All Sizes
HIGH SPEED TRACK LAYING ARTILLERY TRACTORS
CAPTIVE BALLOON WINCHES
AIR FIELD SERVICE TRACTORS
AIRPLANE CRASH TRUCKS • FIRE EQUIPMENT
AIRPLANE WRECKING TRUCKS
MOBILE AIRCRAFT MACHINE SHOPS
MOBILE OXYGEN GENERATOR UNITS
MOBILE WATER PURIFICATION UNITS
AIR FIELD ROTARY SNOW REMOVAL EQUIPMENT
AIR FIELD FUEL SERVICING TRUCKS

☆

We are Specialists in the Design and Production of Military Transportation Equipment

MARMON-HERRINGTON CO., INC.

MANUFACTURERS OF ALL-WHEEL-DRIVE VEHICLES
AND HIGH SPEED TRACK LAYING VEHICLES

INDIANAPOLIS, INDIANA, U. S. A.

Purveyors to U. S. Army, U. S. Navy, U. S. Marine Corps and Many Foreign Governments

To escape artillery fire, the detailed location of any object must be completely concealed from the camera. Confusion of the looks of an object to escape from a bomb hit is another matter. In the case of a bombing operation, the enemy already knows exactly where the object is located on the map. However, while artillery can fire accurately, an airplane can only bomb what the bombardier actually sees.

"Consequently, the camouflage of large industrial plants is based on the hope that it can confuse the mission of the attacking airplane until it is brought down by gunfire, or that it can drive an enemy into area bombing rather than into specific bombing. As the enemy pilot requires at least a minute to prepare to drop his bombs, he must recognize his target from a distance of five or six miles. At that height even a large factory appears no bigger than a postage stamp. The bombardier must press his bomb-release at exactly the right instant. If the bullseye can be so blurred that the bomber must take more than one run before passing directly over his target, his danger is increased, his efficiency greatly diminished, and camouflage has served its purpose."

THE SOLDIER'S HANDBOOK, CONTAINING BASIC military information for enlisted personnel of all arms and services of the Army will be distributed free to every officer and enlisted man. Prepared by some of the foremost experts of the Army, the handbook is the first of its kind to be issued since the World War. Appreciating the completely changed environment in which the great majority of the enlisted personnel of the Army of the United States will find themselves, the handbook was prepared to help them over the rough spots as rapidly as possible during their transition from civil to Army life. Additional copies may be secured from the Superintendent of Documents, Washington, D. C., at thirty-five cents each.

VIBRATION CAN'T LOOSEN THESE NUTS

RESILIENT NON-METALLIC LOCKING COLLAR automatically eliminates thread play and holds load-carrying thread faces in constant pressure-contact • ***Write for Catalog.***

ELASTIC STOP NUT CORPORATION
2338 VAUXHALL ROAD • UNION, NEW JERSEY

Elastic Stop SELF-LOCKING NUTS

Book Reviews

THE ARMED HORDE. By Hoffman Nickerson. New York: G. P. Putnam's Sons.

THIS book presents a striking and interesting paradox. At the very beginning, the writer deplores but still approves our own transition from a professional or semiprofessional army to that which long has been known as the "nation in arms," but which he prefers to call the "armed horde." He goes on to analyze the nature of both professional and mass armies and to contrast them, although he admits that the two extremes approach each other—"a conscript body of some training, with professional officers and noncoms, has much in common with a professional force meant to be diluted with reserves to bring it to war strength."

Nevertheless, he finds a definite contrast: The professionals "fight from disciplined habit. Their *esprit de corps* is not unlike a strongly developed school or college spirit. Their sense of the honor of arms has much in common with that of a clergyman who will not disgrace his cloth, or a good workman who would be ashamed to do a bad job. Thus they are ordinarily obedient instruments of the governments which pay them. They need no violent emotion to make them fight. Temporary troops, on the contrary, can have no comparable professional spirit. Their opinions are in general those of the community from which they come; most of them will willingly face hardship and danger only when filled with emotion. You must tell them that they are fighting for God and righteousness against enemies who are the spawn of Satan."

For a further contrast—"professional troops represent military quality, since in peace they can give their whole time to training. At the same time their numbers are limited by the expense of keeping them always under arms. Conversely, temporary soldiers cannot achieve the same standard of military quality because they do not give their lives to war and the preparation for war, but they can achieve quantity—*i.e.*, numbers—because the community does not have to support them between wars."

The armed horde is naturally the weapon of savage tribes, but past civilizations have sought to rid themselves of it. During the last 150 years, civilization has recreated it. Since the French Revolution, the mass army has dominated war, and democratic ideas have dominated politics. The two together, the writer says, tend to barbarism.

What could be more pessimistic? Yet in the end the writer finds indications that the mass army contains within itself the seeds of its own disintegration. He suggests that the present mechanized warfare is tending again to professionalism and points out that loss of life is small in comparison with preceding wars. Here is an optimistic concluding note. What are the high lights of the connecting chapters?

First the author casts a glance at Greece and Rome and shows how each state started with a civic militia and passed to a mercenary system when campaigns grew long and hard. Then came barbarian pressure from the north and the advent of the horde into Europe, when society organized itself for defense on the feudal militia plan. The Empire became Christendom, and the Church took steps to limit war.

The defense system again weakened, and there arrived the mercenary in his worst form. The Thirty Years' War marked the lowest moral point of armed conflict. The lawyers then attempted to limit war, so that "soldier made war on soldier" only, and treaties commanded respect. To such an extreme did limitation go that eighteenth-century war became overformalized and ineffective—so ineffective, that the energetic French Revolu-

DYNAMIC BALANCE

No Power Loss
ON TURNS

Through the perfection of an ingenious but simple method of gearing, CLETRAC engineers have made it possible for CLETRAC crawler tractors to make turns without having the power disconnected on one track and forced on the other track! Each track gets its full share of engine power by means of this *exclusive differential steering* method. Perfect safety and control is assured when going down-grade with the tractor coasting, and the load pushing. BUILT TO ENDURE, CLETRAC gives longer DEPENDABLE tractor life.

THE CLEVELAND TRACTOR CO.
CLEVELAND, OHIO

Cletrac
Crawler Tractors

KENNAMETAL
TURNING and
PRECISION BORING
TOOLS

Help Maintain Uniform Production On the New Garand Rifle

At the U. S. Armory in Springfield, Mass., four KENNAMETAL-tipped tools are used in a Fay-Automatic machine to rough turn caliber .30 barrels for the new Garand rifle. Each tool in the set of four wears uniformly, assuring maximum efficiency from the machine. Tools are ground every 200 pieces, and average 12 regrinds per tool or at least 2,400 pieces per set. Speed of cutting is 200 feet per minute; depth of cut, ⅛-inch.

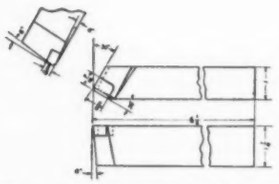


Fig. 1. KENNAMETAL tool for turning cal. .50 rifle barrels at the Springfield Armory. Tip is KENNAMETAL Grade KM.

KENNAMETAL tools are also used at Springfield Armory for turning caliber .50 barrels (tool shown in Fig. 1). Here, too, they maintain a high, uniform rate of production.

In addition to uniform production schedules, the Springfield Armory requires close tolerances on vital parts. Solid bars of KENNAMETAL K3H (see Fig. 2) are used for precision boring of chamber in the breech of the gun, with interrupted cutting on a cylindrical section. Use of KENNAMETAL on this operation permits very close tolerances with a smooth finish, and assures uniform results. KENNAMETAL, the reliable carbide tool material, is also being used at other government plants and scores of other factories producing armaments for National Defense. Let us explain how KENNAMETAL can help maintain uniform, high production in *your* plant. Write today.

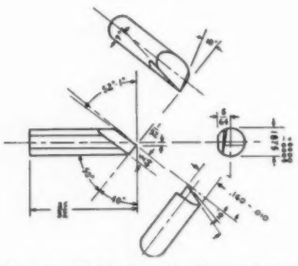


Fig. 2. Solid bar of KENNAMETAL Grade K3H, used for precision boring chamber for the Garand rifle.

McKENNA METALS Co.
331 LLOYD AVENUE
LATROBE, PENNSYLVANIA, U.S.A.

tion would have none of it. The theory of democracy became embodied in a practice of regimentation, and the whole nation made war. Again the horde had arrived, this time under the colors of democracy. The author traces the course of the development in a series of well-selected and well-stated historical examples.

After the Revolution and Napoleon, the horde idea weakened in practice, but in principle it remained—demanded by needs actual or prospective and urged by the great theorist Jomini and the greater philosopher Clausewitz. For this period the striking example is our Civil War. The experience of this war did not come to full utilization for many years, for immediately after it came the Austro-Prussian War of 1866 and the Franco-Prussian War of 1870 which obscured its lessons. These European wars crystallized into permanent form the essentials of the horde, and developed staffs adequate to render it manageable. The Prussians, uncompromisingly a mass army, swiftly overcame the French, who tended toward professionalism. This was taken as a demonstration of the superiority of the mass army, and all Continental European nations adopted it. Dazzled by this brilliant success, military students forgot that there had ever been a war before, and based all their theory and practice upon that latest struggle.

During all this time the political tendency had been toward democracy, and the mass army was taken to be the normal tool of an exaggerated (and paradoxically regimented) democracy. In 1918, all Europe, semidemocratized but inexpert in democracy and committed to the horde theory, organized itself into groups of allies whose mass armies fought each other practically to the last man. With the development of mechanization, the war became more and more mechanized, and the center of gravity shifted from the front lines toward the factory. Only the advent of the Americans made possible a military victory instead of a victory by collapse. The writer thus summarizes the 1918 situation:

"The wheel had come full circle. In 1814 the Prussian royal house had systematized the armed horde. For over a century . . . they had successfully wielded this ponderous instrument which had been the logical product of revolutionary democracy. . . . As defeat approached in 1918 . . . mass warfare returned to its revolutionary origins, overthrowing the Hohenzollerns who had perpetuated it. . . . Horde warfare, so long impotent to win victory and so wasteful in winning it, made real peace impossible."

Between 1918 and 1938, theory ran wild. One school of thought announced that armies and navies were obsolete; that nothing counted but an air force; that nothing was worthy as the target of that force but the whole area of the enemy's country, and that such an attack in mass would break national morale overnight. Another school, which thus far has proved more realistic, insists that all arms remain essential; that they simply must reorganize themselves to take advantage of mechanical development. Everything that has happened, up to Dunkerque, tends to substantiate the second theory; everything since Dunkerque tends to disprove the first.

Touching upon the numerically small losses of the present war as compared with the preceding one, the writer closes on a mildly optimistic note: Mechanization itself compels a degree of professionalism; hence a tendency to subordinate the mass. "It is at least permitted to hope that the descending curve of war may be a preliminary to better things, that our children may refuse to be crushed either by dictators or by governments calling themselves democracies."

It is a pleasure to note the emphasis laid upon the writings of the late Robert M. Johnston, and upon the fulfillment of so many of his prophecies.

The book is so comprehensive and so closely reasoned that no mere review could follow out its train of thought and its strikingly original study into the nature of democracy. For this, nothing will do but to read the book, and it is a book that one should not miss. O. L. S.